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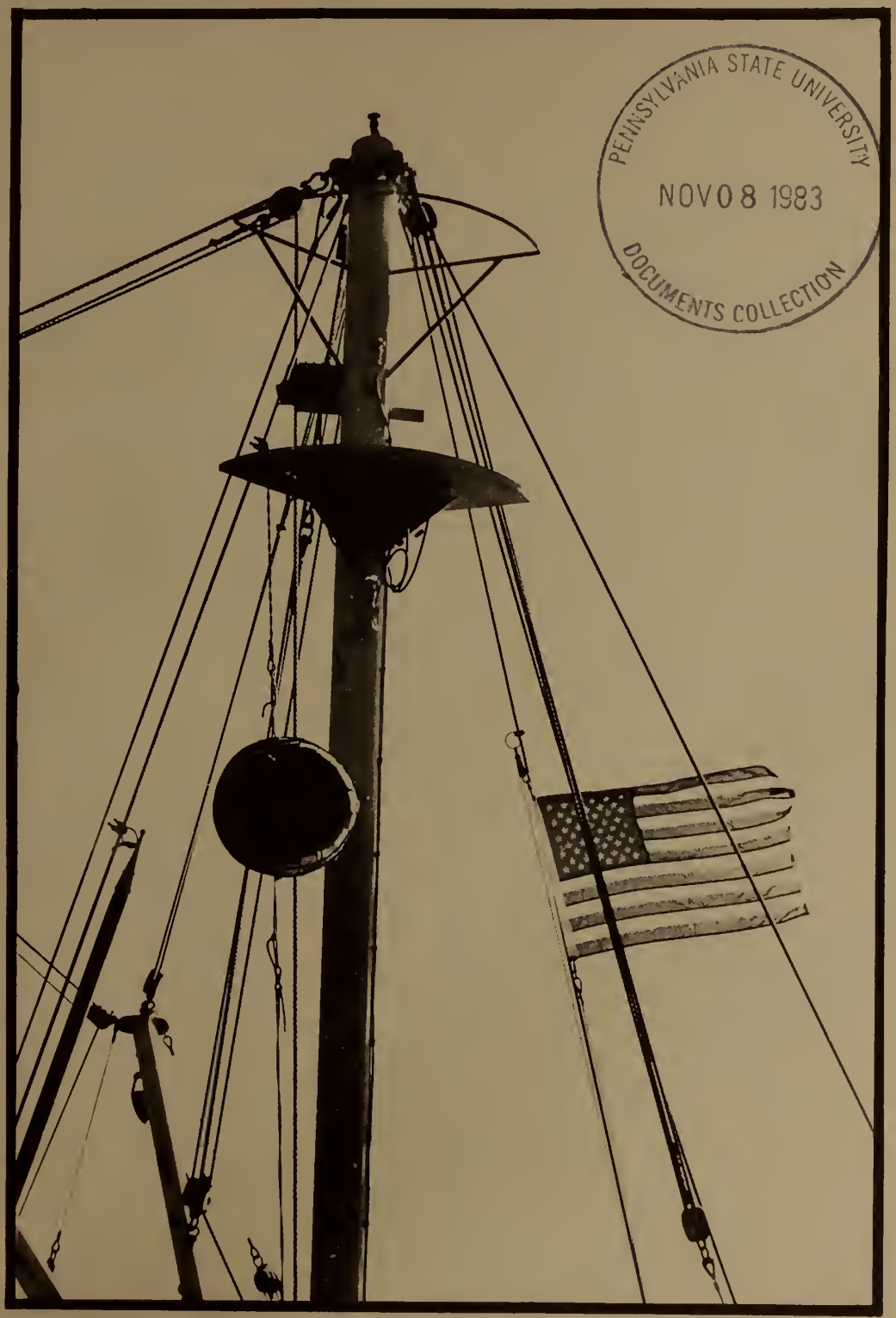
FROM SEA TO SHINING SEA



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SEA GRANT BIENNIAL REPORT
1 OCTOBER 1979 - 30 SEPTEMBER 1981

U.S. Department of Commerce • National Oceanic and Atmospheric Administration • National Sea Grant College Program

1979–81 Sea Grant Biennial Report

From Sea to Shining Sea

A Biennial Report of Sea Grant Activities on the Marine and Great Lakes Coastlines

1 October 1979 to 30 September 1981

U.S. Department of Commerce
Malcolm Baldrige, Secretary

National Oceanic and Atmospheric Administration
John V. Byrne, Administrator

National Sea Grant College Program
Ned A. Ostenso, Director

U. S. Depository Copy

THE SECRETARY OF COMMERCE
Washington, D.C. 20230

The President
President of the Senate
Speaker of the House of Representatives

Sirs:

I am pleased to submit the 1980-1981 Biennial Report of the National Sea Grant College Program in accordance with Public Law 94-461, October 8, 1976.

Also enclosed are comments from the Director of the Office of Management and Budget and the Director of the Office of Science and Technology Policy. These comments are submitted in accordance with Section 211(b) of Public Law 94-461.

Sincerely,

Malcolm Baldrige

Secretary of Commerce

Enclosures

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A Message from the Director

During the past two years we have seen a great maturing of Sea Grant as a national program. With the addition of the fourteenth and fifteenth Sea Grant Colleges during the biennium, the network of fully developed programs expanded while the institutional programs continued to make significant progress toward that goal.

Therefore, the attention of the Office of Sea Grant, the Sea Grant program directors, and the publics they serve turned increasingly toward fully realizing the potential inherent in this national network. This was evidenced during the biennium by the formalization of the Council of Sea Grant Directors into a management entity, the strengthening of the Sea Grant Association as a force in the marine affairs of the Nation, and the development of long-range strategies for Sea Grant endeavor in the social sciences, law, and aquaculture.

Along with the maturing of the Sea Grant Program came a serious reappraisal throughout the Federal Government of its proper functions, with an eye to reducing the burden of government on the governed. The ability of the National Sea Grant College Program to attract increasing levels of non-federal support and grow to its present status, along with its accomplishments, has indicated that Federal funding is no longer needed. Thus, the President has proposed the phase-out and termination of Federal support for Sea Grant.

FISHERIES

The U.S. fishing fleet has been harvesting more and more fish. Yet the demand for fish and fish products is so great that we still import a great part of our supply. Fish, in fact, represents 28 percent of our national trade deficit for non-petroleum products.

The Fishery Conservation and Management Act of 1976 solved part of the problem of exploitation of domestic resources. The Act set up the fisheries conservation zone—the tract from 3 to 200 miles out to sea—where American fishermen get first rights. But even with these matters settled, other problems confront the U.S. fishing industry:

- declines in populations of traditionally fished species;
- increases in the cost of fuel;
- overinvestment for specific fisheries;
- competition from foreign suppliers; and
- declining prices when catches are best.

Managing fish stocks continues to be a major problem. The Act assigned jurisdiction over fish in the fishery conservation zone to eight regional fisheries management councils. State agencies still regulate fish stocks in the territorial sea—the first three miles—where most fishermen fish. While the regional fisheries councils try to set up coordinated management practices within the territorial sea, their efforts have had limited effectiveness.

State fishery agencies rarely have the resources to deal with the biological and economic assessment of non-traditional species—even though exploiting non-traditional species might bring in significant revenues. While regional fishery development foundations often support this kind of research, it must compete with higher priorities, such as increasing harvests and selling seafood.

So the National Sea Grant College Program has been developing ways—with Federal and state fishing agencies and regional management councils, fishery commissions, and development foundations—that the fishing industry can get full use of the living resources of the oceans and Great Lakes.

Through its advisory program, Sea Grant has the unique capability to identify problems. And through

The Fishery Conservation and Management Act solved part of the problem of exploitation by setting up a tract where American fishermen get first rights. But even with these matters settled, other problems confront the U.S. fishing industry.

the most extensive source of talent in fisheries—the Nation's academic and research institutions—Sea Grant has the capability to solve them.

Most problems addressed by Sea Grant during the last two years have fallen into two areas: helping fishermen, and understanding the biology of harvested kinds of fish.

To help fishermen, Sea Grant has looked at the following:

- Soaring fuel costs—a problem for fishermen around the country—may at some point be partly solved by using sail-assisted fishing vessels, according to studies in the northeast, mid-Atlantic, south Atlantic, and Gulf coasts.
- Studies conducted throughout the network investigated and identified techniques for conserving fuel on existing fishing vessels.
- Studies to improve the efficiency of baits and traps have been conducted on the east and west coasts and the Great Lakes. Work has been done on improving trawling gear.

Biological research has included:

- behavioral studies to learn how fish relate to their environment;
- population studies to help determine how much fish we can harvest without damaging the stock; and
- community studies to estimate the consequences of harvest for other resources or the effects of environmental changes on harvest.

Sea Grant is helping to develop new fisheries around the country: tilefish, swordfish, pelagic shark, croaker, and mullet in marine waters; pink salmon and sucker in the Great Lakes. In developing these fisheries, researchers collect biological information and assess potential for commercial or recreational harvest. Sometimes this information is useful for building a management plan.

Stock assessments have included many commercially valuable species But not all work has focused on commercially important species; assessments of recreational species include lake trout, lingcod, salmon, snapper, and grouper.

- Working in conjunction with the Oregon Department of Fish and Wildlife, Sea Grant investigators there studied the distribution, abundance, and species composition of hardshell clams. Their goals were to understand biological differences between subtidal and intertidal gaper clams, and to evaluate the effects of commercial harvesting of subtidal clams. Based on this study, a pilot program for subtidal clams in Yaquina Bay, Oregon, now yields a sustainable harvest.
- Sea Grant in Georgia continued

The National Sea Grant College Program has been developing ways that the fishing industry can get full use of the living resources of the oceans and Great Lakes.

to assist hard-pressed shrimp fishermen. Sea Grant adapted a typical shrimp boat for multiple-purpose fishing—with hook and line, longline, traps and pots, or heavy trawls. Fitted with fish-finding sonar and a Loran-C navigational system, the vessel now demonstrates its capabilities to shrimp fishermen. Modification of shrimp boats to use any or all the gear demonstrated would enable fishermen to fish for species other than shrimp and help them to fish longer at more locations making them less dependent on fluctuating shrimp stocks.

- Since 1965, a great deal of Federal and state effort has been expended to reestablish lake trout populations in the Great Lakes. Although 6.5 million fish are planted yearly in the Great Lakes, no naturally reproducing populations have been established. Researchers in Wisconsin are developing management strategies for reestablishing self-sustaining stocks in the Great Lakes. Success could save many millions of dollars for the Federal and Great Lakes states' governments.
- Although Florida fishermen harvest 17 million pounds of hardshell blue crabs annually, they rarely harvest softshell blue crabs (the newly shedded hardshell crabs)—a high-priced delicacy. Sea Grant advisory staff, recognizing the potential for a softshell crab industry in Florida, showed local fishermen the Chesapeake Bay technology. As a result, the state now has a new fishery worth about $1 million annually. Current projections indicate that the fishery can be expanded.

Sea Grant's fishery program is dynamic and flexible. Like most Sea Grant programs, it is set up to respond to identified needs or new problems, while simultaneously ex-

Commercially Important Species for Which Sea Grant Research Has Provided Biological Information to Fisheries Managers.

Species	*State*
Swordfish	Florida
Ocean quahog	Massachusetts
Hard clams	Georgia
Sand launce	Maine/New Hampshire
Tilefish	New Jersey
Croaker	Texas
Lake whitefish	Wisconsin
Suckers	Minnesota
Eels	Georgia
Herring	Alaska
Sharks	Virginia
Butterfish	Virginia

In 1981 Sea Grant sponsored 149 projects in fisheries at $4.2 million. These include organism studies, population studies, community studies, and fisheries studies. Twenty-four of the Sea Grant institutions have supported projects in fisheries.

ploring the resources of the oceans and developing ways to use and manage them. Sea Grant has sought to develop information, techniques, and procedures to facilitate full use of American fishery resources. Through the talent of the Nation's academic and research institutions, this goal can be achieved.

Highlights

During the past two years Sea Grant supported fisheries research at 170 colleges, universities, and research institutions. Here are a few highlights:

• Smoltification is a physiological change in salmon that enables them to adapt from freshwater to saltwater. Understanding smoltification is essential for hatchery operations. The closer to smoltification a young salmon is when released, the greater are its chances for survival. Research in California, Washington, Oregon, Minnesota, and Massachusetts has already unlocked enough secrets of this critical natural process to make commercial salmon "ranching" a possibility.

• The success of a fishery depends on how many fish reach harvestable size; this number is called recruitment. Three Sea Grant institutions —Delaware, Maryland, and Virginia —are cooperatively studying factors that affect blue crab recruitment in the mid-Atlantic bight. Adult crabs spawn at the mouth of the Chesapeake Bay; the eggs and larvae drift offshore where they mature; and water movement draws mature larvae back into the bay. Findings suggest that recruitment depends on the environmental factors that influence the larvae's movement back toward shore. Managers can use these conclusions to forecast the level of harvest.

Through its advisory program, Sea Grant has the unique capability to identify problems. And through the Nation's academic and research institutions, Sea Grant has the capability to solve them.

AQUACULTURE

As natural stocks decline under pressure from commercial harvests, aquaculture research can provide new technologies to supplement the world's protein supply.

In the United States we aim to catch just about as many fish as we possibly can without diminishing the fish population—a balance that fishery managers call maximum sustainable yield. We import more than 60 percent of our fish products. This represents more than a $2.5 billion trade deficit (equivalent to 10 percent of the national trade deficit and 28 percent of the deficit for non-petroleum products).

Currently the total aquaculture production in the United States—about 94,000 metric tons (200 million pounds)—is about 6 percent of the edible fish caught. Aquaculture products have a wholesale value of about $200 million and a retail value of nearly a billion dollars.

Since its beginning in 1968, Sea Grant has been committed to aquaculture.

The National Aquaculture Act of 1980 made aquaculture development a national policy and called for a coordinated program involving 13 Federal agencies and departments, with the National Marine Fisheries Service and Sea Grant conducting this research. In addition, Sea Grant will meet as many of the education, training, and advisory service needs of marine aquaculturists as its resources permit.

Highlights

In March 1981 a task force of Sea Grant directors identified nearly $22 million of annual benefits in the field of aquaculture, including Sea Grant research on crayfish farming, pen-reared salmon, oyster culture in natural and controlled environments, ocean ranching, disease control in salmon and shellfish cultures, freshwater prawn cultures, and assistance to the newly developing shellfish industry in Maine.

How much can aquaculture grow? Americans eat more and more fish. In 1960, the average American ate 10.3 pounds of fish, in 1977, 12.8 pounds, and in 1980, 13.6 pounds. And with fish and shellfish ranking high on the list of consumer health foods, the trend continues.

Aquaculture can:

- reduce the balance-of-payments deficit;
- provide more fish and fish products for Americans;
- provide more stability for our seafood industry through additional jobs and increased revenues;
- develop export markets;
- provide low-fat, high-quality protein for domestic and foreign consumers; and
- improve the recreational potential of our marine waters.

Impediments to aquaculture development. America's fledgling aquaculture industry shows promise, but technical, social, and economic factors stand in the way of full growth. Indeed, specific research and extension efforts by the Sea Grant network can remove many of these barriers.

These research areas have been identified as the most important needs by collective input from industry, academia, and government:

- crustacean reproductive physiology;
- carrying capacity (ecology) of environment for ocean ranching and mollusk rafting;
- selective breeding and planned

In March 1981 a task force identified nearly $22 million of annual benefits from Sea Grant's work in aquaculture.

applied genetics for marine finfish, marine shrimp, mollusks, and prawns; nutrition and feed development for marine finfish, mollusks, marine shrimp, and prawns;

- aquaculture pond dynamics (stability, productivity, and reliability), involving mollusks, crustaceans, fishes, and polyculture systems;
- avoiding disease, predation, contamination, and stress in aquaculture production systems involving marine finfish, mollusks, and marine shrimp;
- facility engineering for reduction of labor, costs, and energy for all species in production;
- development of procedures for drug, seed, and product certification for interstate shipment, transplanting, and sale for all species;
- improving seed hardiness and survival in mollusks and crustaceans; and
- marketing economics and product development for those species where lack of markets is restricting the industry.

Crustaceans (shrimp, prawns, etc.). Marine shrimp culture is a reality for 15 to 18 firms in the United States and Latin America. Additionally, several firms plan to start farming shrimp in Texas. Texas and California researchers are looking at controlling shrimp maturation and reproduction, nutrition, culture requirements, genetics, and shrimp diseases.

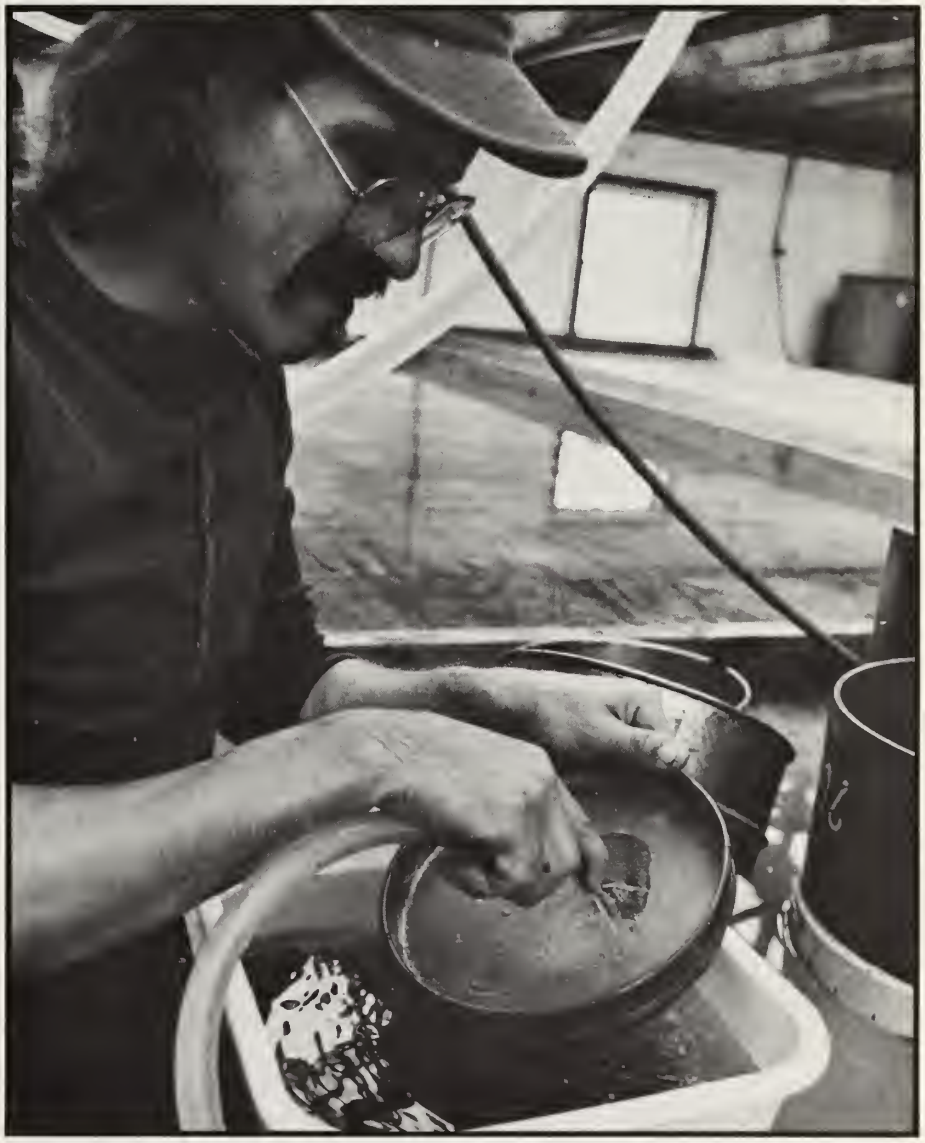
Sea Grant research at Texas A&M has contributed to a recent breakthrough in the ability to mature, mate, and produce marine shrimp offspring in captivity. However, the technology is not yet advanced enough for commercialization in the United States.

In the field of nutrition, a University of Rhode Island researcher has shown that environment may have a significant effect on the nutritional value of brine shrimp and their ability to accumulate and pass on pesticides. Aquaculturists commonly feed brine shrimp to young life stages of fishes and carnivorous shellfish, including marine shrimp and lobsters.

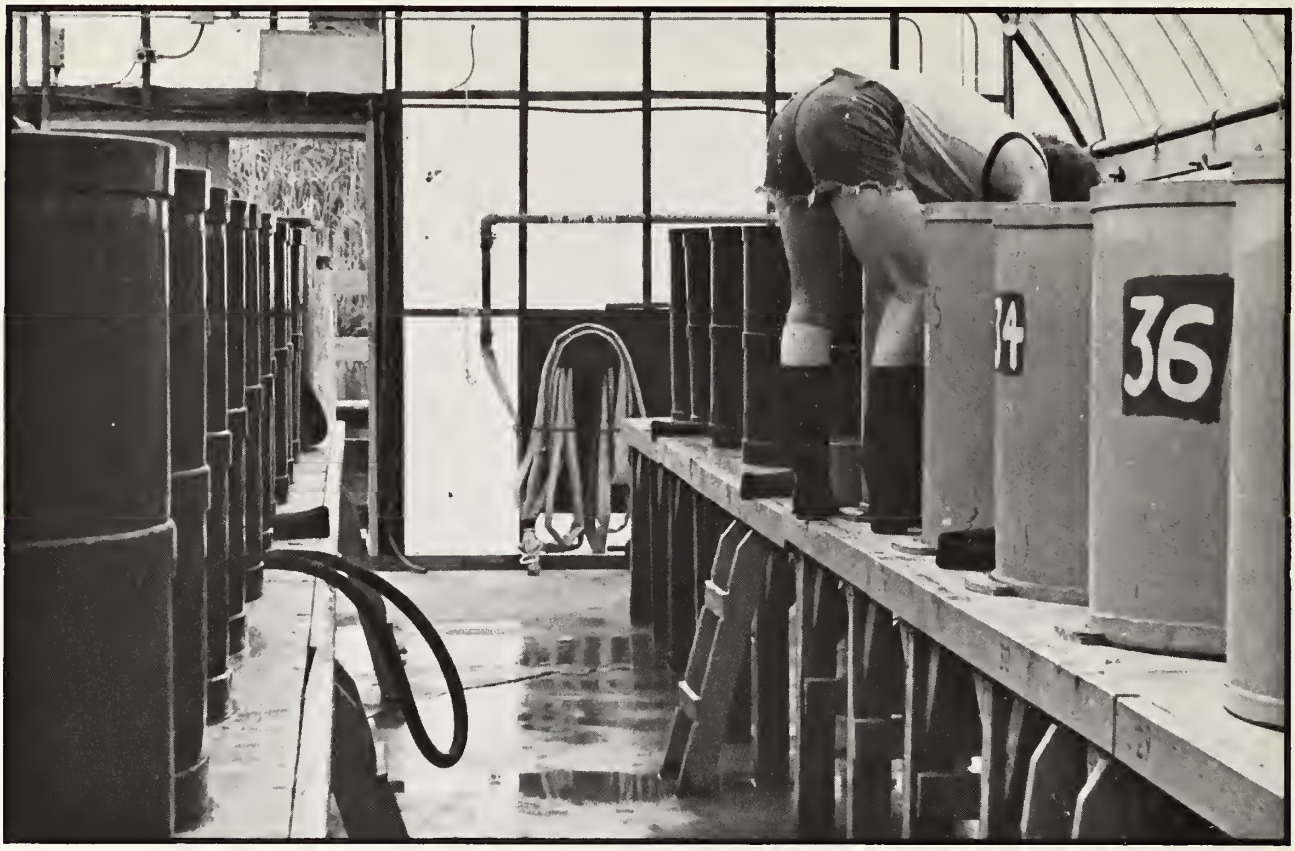
Currently, 22 American firms—21 in Hawaii and 1 in California—grow prawns. Annual production has reached the current harvest of 300,000 pounds, about $1.2 million worth. Sea Grant efforts involving freshwater prawns (*Macrobrachium*) have resulted in the development of improved feeds, adjustments in commercial stocking procedures to improve production, and the implementation of a data collection and management system for commercial prawn farmers.

In 1960 the average American ate 10.3 pounds of fish, in 1980 13.6 pounds. With fish and shellfish ranking high on the list of consumer health foods, the trend continues.

Finfish. The Pacific salmon is probably the most valuable com-



Aquaculture is to water—marine or fresh—what agriculture is to land. It is the cultivation of marine plants and animals under controlled conditions. Sea Grant has been funding and directing research on aquaculture of many species.



All tanks must be cleaned, all ingredients measured, all progress monitored at an aquaculture hatchery. Aquaculture offers untapped opportunities for producing food, boosting the economy, and promoting industry.

mercial, recreational, and subsistence fishery in the United States. Current salmon aquaculture production is estimated at 7.6 million pounds, worth $3.4 million. Salmon can be grown in net pens or by ocean ranching. Ocean ranching involves releasing salmon to grow and fatten at sea for several years and then waiting for them to return to the site of their release, where they can then be harvested. At least 20 projects around the country involve salmon culture.

Sea Grant researchers provide aquaculturists with checkups and treatments for their fish and shellfish. As the industry grows, it is expected that these services will be taken over by state and private organizations.

The University of Washington's Sea Grant salmon projects have contributed to significant reductions in prespawning and presmolting deaths due to bacterial kidney disease in spring chinook salmon. In addition, a quantitative smoltification index has been developed that allows commercial growers to predict the best time to transfer young salmon from freshwater to seawater, thus reducing mortality in the young fish.

University of Washington researchers have been able to increase the egg production of coho salmon broodstock some 65 percent over two years by genetic and nutritional manipulation. Finally, the testing of various artificial incubation substrates for chum salmon has increased chum fry quality significantly; these new techniques are now being applied by the Washington Department of Fisheries and by private ocean ranchers in Alaska.

A small project was funded in 1979 at the University of California to look at sturgeon hatchery technologies. Since then this program has been funded by grants from both the Department of the Interior and the Department of Commerce. Though the program is young, the work has indirectly resulted in the development of a fledgling aquaculture industry in California and has led to legislation allowing the sale of cultured sturgeon in the state.

Mollusks (oysters, clams, etc.). About 500 companies grow oysters in the United States. In 1980, they grew 23.7 million pounds of oysters, worth $37 million.

Maryland has developed new tech-

Through its aquaculture program, Sea Grant is fostering the development of an aquaculture industry in the US.

niques to produce oyster seed for planting in the Chesapeake Bay region. Oyster growers in the Pacific northwest have adopted recent advances in oyster growing technology including the use of eyed larvae as an oyster seed source (Oregon State University). At the University of Washington, hatchery genetics studies are producing strains of oysters resistant to summer mortalities. This has been accomplished by selecting for those oysters that have low reproductive capability at the typical ambient water temperatures. These oysters have higher survival rates than those that spawn at typical temperatures and are now being introduced as broodstock in commercial hatcheries.

Most of our clam aquaculture industry is devoted to culturing the hard clam (*Mercenaria mercenaria*). Seven American companies grow clams, producing about 4 million pounds of clams worth over $10 million annually. A Sea Grant clam research project at State University of New York (SUNY) has worked with the towns on Long Island, New York, to evaluate the practice of planting seed clams. As a result, East Hampton Township has planted 20 culture rafts for public clam seed production, and Brookhaven has stopped spending money on spawner transplants because research has shown the technique to be ineffective.

Aquaculture diseases. Sea Grant researchers in Oregon, Texas, and New York provide aquaculturists with checkups and treatments of their fish and shellfish. Thousands of fish, shrimp, and bivalve shellfish have been examined at several dozen private aquaculture firms, state fish and wildlife units, and universities. As the aquaculture industry grows, it is expected that these services will be taken over by state and private organizations.

Plants. Growing seaweeds for human food, animal food, and fertilizers is popular in Southeast Asia and Japan. Natural products extracted from seaweeds, for example, algin and carrageenin, are used as stabilizers in foods and paint. And some marine plants can produce energy supplies through biomass conversion as well as food developed as salt-tolerant food crop producers. A number of Sea Grant efforts are directed toward cultivating seaweeds (University of California, University of Hawaii, State University of New York and University of Washington). The Washington Department of Natural Resources is currently pilot testing a net culture system that can produce 200 tons per year of carrageenin-producing seaweeds.

Two unique studies involve:

- using seawater for irrigation of such commercial crops as barley and tomatoes (University of California); and
- developing new food and forage crops from salt-tolerant marsh plants (University of Delaware).

New York Sea Grant is developing ways to produce marine biomass from seaweeds; Mississippi Sea Grant is using marine algae for producing alcohol in wastewater recovery.

Through its Aquaculture Program, Sea Grant is fostering the development of an aquaculture industry in the United States.

America's fledgling aquaculture industry shows promise, but technical, social, and economic factors stand in the way of full growth.

Sea Grant promotes aquaculture development in salmon, marine shrimp, freshwater prawn, oysters, clams, and seaweeds. During the biennium Sea Grant conducted 226 aquaculture-related projects, involving $8 million in federal Sea Grant funds and more than $5 million in matching funds.

Aquaculturists grow clam seed in hatcheries to plant in open waters. Larger, older seed—less vulnerable to predators—has a better survival rate. But growing seed larger costs hatcheries more.

ENVIRONMENTAL STUDIES

The marine resources of our country include not only the living resources of the fin- and shellfisheries, but also the use of our coastal waters, estuaries, and adjacent coasts for transportation, industry, and recreation. Wise use of these resources requires an understanding of the impact that natural events and man's activities will have on them. Often, uses that appear to be in direct conflict are seen to be, when the scientific facts are known, reconcilable if not compatible. The purpose of the Sea Grant environmental research, education, and advisory program is to provide unbiased information to the public, their elected representatives, and agency managers, so that informed decisions on resource use can be made. Although environmental research, by its very nature, is carried out at a specific location, Sea Grant research addresses national questions:

- What is the contribution of wetlands to the fisheries productivity of our coastal waters?
- Can we develop better methods of predicting outbreaks of paralytic shellfish poisoning so that shellfish production can be increased and human health protected?
- Where do the PCBs in the Great Lakes go and how long will they linger in the lakes' fisheries?

Answers to these and other questions of national importance are being found by Sea Grant research scientists and engineers. Working closely with the researchers, Sea Grant education and advisory staff make these results accessible to the public and to those who must make critical decisions on the use and allocation of our Nation's marine resources.

Highlights

Cholera and other pathogenic vibrios. In the 1970s, Sea Grant researchers in Maryland found evidence that *Vibrio cholerae,* the virus that

The Sea Grant environmental program provides unbiased information to the public, their elected representatives, and agency managers, so that they can make informed decisions on resource use.

causes cholera, was naturally present in the marine environment. In 1978 the first cholera outbreak in the continental United States since 1911 occurred in Louisiana. An embargo on the sale of Louisiana blue crabs, which have an annual landing value of $3.5 million, could have resulted. A Sea Grant research program was quickly organized that would:

- find out the incidence and geographic distribution of the virus;
- determine the environmental factors that control its distribution;
- establish rapid, inexpensive, standard methods for identifying vibrios associated with shellfish and their waters; and
- develop, in conjunction with Sea Grant marine advisory services, a public education program on the proper handling, processing, and marketing of shellfish.

Coordinated by the Maryland Sea Grant Program, the study called on scientists from the Maryland, Louisiana, and Oregon programs, and later, from Florida. The research has shown that:

- Naturally occurring *Vibrio cholerae* is found in estuarine waters on the east and west coasts.
- Properly processed and handled seafoods are safe for human consumption. All cholera cases to date have resulted from private individuals improperly handling seafood; no cases have come from eating commercial seafoods.

Northwest Hawaiian Islands Fisheries study. In cooperation with the National Marine Fisheries Service, the Fish and Wildlife Service, and the State of Hawaii, the Hawaii Sea Grant Program is evaluating the fisheries resources of the Northwest Hawaiian Islands chain. The Sea Grant part of this joint research effort consists of 12 projects, 4 of which are already completed. Projects address the productivity of the planktonic and benthic communities, the relationships between the fish communities and their natural predators, and the economic and management issues that must be clarified to use this fisheries resource wisely.

Atchafalaya Delta program. While statistical correlations suggest that the more wetlands available the greater will be the yields of important fish, the ecosystems involved are complex and difficult to understand. The rapid growth of new wetlands in Louisiana's Atchafalaya Basin provides a chance to understand the development of a major coastal ecosystem and to document its evolution.

The program currently consists of nine projects that address questions of circulation, sedimentation, nutrient dynamics, and primary and secondary productivity in marshes, the bay itself, and offshore waters. Although the program began only in 1981, it has already produced maps and reports describing the physical growth of the delta. The program has attracted the interest of a wide range of Federal agencies, state agencies, and private firms, and has led to the support of two complementary projects by the Corps of Engineers.

Green Bay program. Green Bay is the major freshwater estuary in Lake Michigan, heavily used for recreation, transportation, fishing, and waste disposal. Over the years, water quality in the bay has become severely degraded with subsequent decline of both commercial and recreational fisheries and other recreational uses of the bay. Early work in Green Bay by the Wisconsin Sea Grant Program developed a foundation of information about the bay. A surge of interest in rehabilitating Green Bay by the state, by private citizens, and by industry has led to the development of a new research program coordinated by Sea Grant with academic, industrial, and public involvement. The program assists in the solution of resources problems

Growth of new Louisiana wetlands provides a chance to document the evolution and development of a major coastal ecosystem.

Because no one understood what caused outbreaks of toxic dinoflagellates, no one could predict paralytic shellfish poisoning outbreaks. Now Sea Grant scientists have made key discoveries about the organisms' life cycle.

and enhances the natural environment of the Green Bay watershed. Through its research, the program is attempting to understand (1) how water mixes in the bay; (2) the sources, fates, and pathways of material entering or formed in the bay; and (3) the physical and chemical mechanisms that influence productivity.

During this biennium the Green Bay research consisted of nine projects in the Wisconsin Sea Grant Program and one from the Michigan Sea Grant Program. Scientists are looking at physical and chemical limnology of the bay, relationships among nutrients, primary production, and fish production, and are assessing the fates of chemicals in the bay. The program is coordinated at the Green Bay Campus of the University of Wisconsin.

Great South Bay study. Great South Bay is a major estuary on the south coast of Long Island, New York. For over 40 years it has been the greatest hard-clam-producing area of the United States.

Since 1976 clam production has declined—for reasons that are not yet clear. The Great South Bay study was set up to identify the steps required to restore and maintain the productivity of the Great South Bay clam fishery. The objectives of the program have been to gather the information required to manage Great South Bay and enhance its productivity as a clam fishery, and to help resource managers and users understand how environmental variables relate to hard clam production.

A workshop of people from academia, industry, and management identified 21 research tasks involving research into the physical oceanography, hydrology, nutrient chemistry, primary productivity, and clam biology and ecology of Great South Bay. Most tasks have been completed, and attention is turning to synthesizing the data and educating managers and users about the results.

Paralytic shellfish poisoning. People can get sick and even die from eating shellfish that have ingested a highly toxic marine microalgae belonging to the dinoflagellate family. Outbreaks of these toxic organisms occur on both the North Atlantic and North Pacific coasts of the United States and result in the loss of a large amount of the shellfish resources in those areas. Because no one understood what caused these outbreaks of toxic dinoflagellates, no one could predict paralytic shellfish poisoning outbreaks. Now, Sea Grant scientists at Woods Hole Oceanographic Institute and at MIT have studied the life cycle of the dinoflagellate. A key discovery has been that the organisms form cysts that settle in the sediments to survive the winter. Since the cysts vary in toxicity from location to location in ways that are not well understood, their presence in the sediment does not ensure an outbreak of the toxic organism. It does, however, provide a warning of the possibility. Such a tool has never before been available to public health officials. Scientists in Rhode Island and Alaska are studying the chemistry of the toxins and are attempting to understand how it differs from location to location. The ability to predict outbreaks would produce a dramatic advance in our ability to manage effectively these valuable marine resources.

The environmental studies program in Sea Grant comprised about 170 research projects during the biennium, resulting in an expenditure of approximately $4.7 million in Federal funds each year. Another $2.5 million in matching funds was contributed yearly by participating Sea Grant programs. Of the 27 Sea Grant programs, 25 had at least one environmental studies project under way during this period.

NATURAL PRODUCTS

Marine plants and animals are rich sources of substances of potential value to industry, medicine, research, and agriculture. Sea Grant research is identifying many of these substances, and evaluating their useful properties.

Medically Significant Substances

Many drugs are derived from terrestrial plants; others are synthetic copies of them. In looking for new drugs, scientists look for biological activity—the compound's ability to cause the body to react in certain, predictable ways. The sea is a promising source for the stuff new drugs are made of, for in the past 20 years the sea has given us many new, organic compounds that are biologically active. Most contain combinations of atoms and functional groups we don't find in terrestrial natural products. A few already have become the basis for drugs.

Recent Sea Grant research shows the great number of bioactive organic substances in marine plants and animals. Over the last two years, researchers in organic chemistry and pharmacology have isolated and chemically identified more than two dozen new compounds. Two of these are effective in fighting tumors; the National Cancer Institute plans to study them further. One, when injected under the skin, can "cure" mice infected with certain kinds of tumors. In preliminary tests, a pain killer and anti-inflammatory agent shows commercial potential. Still another new substance lowers body temperature and blood pressure. Also, a compound that the sea whip —a cousin to coral—uses to defend itself is a neuromuscular toxin that may have value in researching or medically treating the human nervous system.

Agriculturally Significant Substances

Some of the new substances are also being tested for their ability to kill or control agricultural pests. People have used chemicals since the days of the Roman Empire to save crops from insects, weeds, and diseases. But these pests still ravage 30 to 45 percent of the world's food, feed, and natural fiber. Even

Over the last two years, researchers in organic chemistry and pharmacology have isolated and chemically identified more than two dozen new compounds from marine plants and animals.

in our relatively sophisticated country, losses are staggering. More than 400 species of insects and mites already have developed resistance to our pesticides. Clearly, the search for new substances—safer, more effective, and more selective—must continue.

Thus far, there has been little experimentation with using marine natural products as insecticides, herbicides, and fungicides and as agents against parasitic diseases of farm animals. But the little that has been done shows promise. In Japan two marine substances already have been commercially exploited. Nereistoxin, isolated from a marine worm, has been found to kill some kinds of insects. This has resulted in the commercial production of its analogue PADAN, effective against rice borers. And kaenic acid, derived from a red algae, kills parasitic round worms, whip worms, and tapeworms.

Researchers at the University of Georgia have shown a number of extracts of marine organisms to be insecticidal or herbicidal—some at levels that warrant further evaluation of their potential—and at the University of California a number of extracts and pure compounds were shown to be effective in warding off such common insects as flies, spider mites, and tobacco budworms. At the University of South Carolina, researchers have isolated from a salt-marsh plant a compound that can make some agricultural insects impotent. These results are encouraging in light of the fact that few comparable leads have come from tests of terrestrial plant extracts during the last several decades.

Chitin and Chitosan: The New Shell Game

Sea Grant has also studied chitin, the stuff shells are made of. In processing crabs, shrimps, lobsters, and crayfish, most of what's left over is chitin. This has become an enormous waste disposal problem, and one that will only become greater with the Environmental Protection Agency's new regulations. Sea Grant is looking for uses for chitin and its derivative, chitosan. This would solve a disposal problem and create a new industry at the same time.

Chitosan is a unique material easily made from chitin. Its chemical structure makes it attractive to industrial scientists. It is a polymer that reacts with metallic ions. That means it can lift certain metals out of solution—an important job in cleaning up wastewater. Chitin can also coagulate organic materials in solution.

In the early 1970s the Office of Sea Grant helped set up a pilot-scale production of chitosan from chitin. Then Sea Grant sent out free chitosan samples to researchers who wanted to study its physical and chemical properties and try to find uses for it. Their experiments show a wealth of properties and uses: chitosan helps wounds heal, chelates heavy metals, and coagulates a wide variety of organics. In addition, the plastic-like substance can be cast into transparent flexible membranes and

fibers that accept dyes.

When cheese is produced, so is a waste product called whey. Whey is 13 percent high quality protein, but its high lactose content makes it indigestible for most people and animals. Sea Grant researchers suggested that chitosan might be used to enhance the value of whey. Chitosan promotes growth of a bacteria that, in the digestive tract, helps mammals digest lactose by breaking it down into its simple sugars. By building up the level of these bacteria in the digestive tract of domestic animals, farmers can enable them to digest whey. Substituting this waste product for more expensive feeds can be a great savings. Researchers have formulated diets of chitosan and whey that could replace up to 20 percent of the feed for some domestic animals.

Polymer scientists in Mississippi theorized that by chemically attaching chitosan to pesticides and herbicides, the chitosan might impart its insolubility and stability, thereby holding these toxic substances in place longer. This would increase their effectiveness, reduce their runoff into water, and lower the amount needed to protect crops. The scientists successfully produced new types of biocides by chemically conjugating chitosan and certain toxins used in agriculture. Successful greenhouse experiments have set the stage for field testing of these new substances.

Sea Grant researchers in Washington have developed a way to produce chitosan fragments with strong antifungal properties. These can stop the growth of tough, soil-borne fungi that damage certain agricultural crops.

Researchers have shown a number of extracts of marine organisms to be insecticidal or herbicidal—some at levels that warrant further evaluation.

The Natural Course

As research with terrestrial materials yields fewer and fewer drugs and other useful products, research on biologically active marine substances suggests great opportunities. As more methods are developed for making substances with marine products, more opportunities are apparent. More than ten years ago the Commission of Marine Science, Engineering, and Resources called for a National Institute of Marine Medicine and Pharmacology to develop these resources, but the recommendation has not been implemented. However, Sea Grant has continued efforts in this field. The study of unusual metabolic products of marine life is an area where marine ecology and the experimental sciences of chemistry, biochemistry, pharmacology, and medicine share complementary interests. These disciplines can fit together to make a focused academic program.

Although most natural substances used medically are produced synthetically for commercial markets, many antibiotics—the penicillins, streptomycin, and the tetracyclines—are complex structures that must be produced by growing strains of the terrestrial microorganisms. Opportunities remain for studying marine bacteria, yeasts, and fungi—and their metabolic diversity—as we look for new antibiotics. As pathogenic microorganisms develop resistance to currently used drugs, we surely will need new ones.

The chemical industry in its present form depends on oil and natural gas. In the short run, we cannot change this situation. But we must find ways to conserve petroleum resources for the future. One possibility is to exploit biomass as a source of chemical raw materials. Scientists are already looking at ways to convert several terrestrial plants and some macroalgae into energy. However, single-celled marine algae, such as zooxanthellae, have not received much attention. The fact that these organisms can be grown continuously on a large scale suggests that they are a possibility.

Seaweeds and other biomass can be "digested" by bacteria to produce methane—an energy alternative to natural gas.

Exploitation of marine natural products requires the efforts of experts in a variety of sciences and the intellectual environment and administrative mechanisms that will promote the collaboration of these experts. In addition, the ability to get to the sea and to work in the sea requires practical knowledge, special equipment, and facilities, including boats and ships that marine-oriented academic institutions can provide. Most of these institutions in the United States are part of the Sea Grant Program and are therefore ideal organizations to develop the field of marine natural products. Sea Grant encourages applied research, interdisciplinary approaches to resource development, and industrial collaboration, and it provides a mechanism for cooperation between scientists and institutions.

MARINE MINERALS

If minerals, metals, and other natural resources can be recovered from the sea and exploited, they will be a source of wealth to the nation.

The National Picture

Valuable minerals abound in our marine environment. As man exhausts his land sources for these materials, he turns toward the seas. Sea Grant research has focused on assessing these resources and their potential for development. Assessing the resources includes evaluating their abundance and finding ways to locate and recover them. Developing them requires understanding the environmental, economic, legal, and commercial factors that affect their use.

Sea Grant has concentrated on a few key resources:

- sand, gravel, and shells—useful in the construction industry;
- manganese nodules—potato-sized clusters of minerals usually resting on the ocean floor; these are rich in manganese, as well as copper, nickel, and cobalt;
- heavy mineral placers—running water deposits heavy minerals (those heavier than quartz) in layers called placers; these deposits are important main sources of gold, tin, and titanium;
- phosphate rock and lode minerals;
- petroleum (oil and gas); and
- groundwater.

Sea Grant supports activities that lead to increased use and commercialization of marine resources. Minerals, metals, and other natural resources, if they can be recovered and exploited, are a source of wealth to the nation.

The business sector wants basic research information before they invest in a new commercial venture with distant, uncertain payoffs. Academicians or Federal agencies can best provide some of this information. Sea Grant is a partnership of academic and Federal resources that can give industry the information it needs to develop its own programs. And at the same time, Sea Grant information is available to government for use in policy making.

Sea Grant supports research that increases our knowledge about marine geological resources and helps us to find ways to better use them or recover them from the marine environment.

In this biennium, 28 projects at 13 different universities focused on the key resources: sand and gravel, manganese nodules, petroleum, and groundwater. This work accounts for $1,951,700 in Federal funds and $884,500 in matching funds.

The total number of projects has remained nearly constant over the past three years. The dollars invested in this field are relatively constant, but inflation has caused a decline in purchasing power. At the same time, however, pass-through funds from other Federal agencies have increased to $312,400.

Highlights

Sand. Sea Grant has already answered most related key research questions—how much sand and gravel is out there; how can we find it, recover it, and use it, and with what environmental and economic impacts. Now the Sea Grant extension arm brings these research results to those who can use them.

Two research projects have not yet been completed: scientists are looking at Chesapeake Bay to determine how much sand is available for beach protection; and Lake Erie scientists are looking for sand suitable for making glass.

Manganese nodules. Research continues on technology, economics, and strategies in resource use. Two current projects examine the technological aspects of the resource. In one, scientists and research engineers have theoretically established, and verified in the lab, that acoustic pulses at specific frequencies can tell the size and areal density of nodules on the seafloor. Other scientists are working on a vehicle that can help find nodules at depths of 6,000 meters.

But finding and recovering the manganese nodules is just one aspect. After extracting the valuable minerals from the nodules, the unused by-products, called tailings, remain as a disposal problem. Hawaii Sea Grant scientists are looking at offshore disposal and other options for disposing of tailings.

Sea Grant is a partnership of academic and Federal resources that can give industry the information it needs to develop its own programs and can give government the information it needs for use in policy making.

Areas of Inquiry

- The seafloor—perhaps we can safely dispose of some wastes on the deep seafloor. Sea Grant is studying the possibilities.
- Sand—where can we find deposits of sand suitable for construction or for making glass?
- Manganese nodules—how can we better locate these deposits of valuable metals? And what are the environmental effects of the way we dispose of the end products or tailings after extracting the valuable metals?
- Petroleum—what are the geotechnical aspects of the seafloor related to platform design and stability?
- Groundwater—are supplies to our coastal communities secure?

Petroleum. Sea Grant is looking for ways to predict natural hazards —geological and hydrodynamic—for the offshore petroleum industry. Engineers are designing and evaluating techniques for underwater observation and offshore structure operations. These techniques are safer and cheaper than sending divers into hazardous areas. Several projects have environmental focuses: in the Arctic, scientists are studying the impact of Port Valdez oil activity on the bay's microbiology; with support from the Alaska Oil and Gas Association, other Sea Grant researchers study the formation, decay, and location of the ice front in the Bering Sea. Biologists and chemists are studying the effects of crude oil and oil dispersants on larvae of commercially important marine species found in Georges Bank. The results are of great interest to prospective oil and gas activities off New England.

Groundwater. Current droughts along the east coast have made many aware of their dependence on groundwater for drinking. Sea Grant has become involved in developing criteria for identifying coastal areas with aquifers sensitive to drawdown leading to pollution or saltwater intrusion, either in carbonate reservoirs common in Florida or sandstone reservoirs more common elsewhere along the eastern seaboard.

Scientists at MIT have developed a numerical model called SWIM (Sea Water Intrusion Model) for predicting the rate and location of saltwater intrusion in coastal aquifers.

COASTAL AND SEAFLOOR PROCESSES

The National Picture

Nearly everywhere water and land meet, shorelines erode or siltation clogs our waterways. Local residents usually need help in facing these problems. But for that, we need to understand better how water and sediment interact. Coastal commerce depends on sound coastal and ocean engineering. But efficient and safe marine engineering design depends upon understanding coastal and seafloor sediment dynamics. We must learn more about coastal and seafloor processes to better understand coastal protection, shoreline erosion and deposition, and seabed stability.

To address these problems, Sea Grant sponsors three kinds of research on coastal and seafloor processes:

- research on the mechanics of sediment movement—fundamental to understanding the causes of most coastal problems;
- research to improve coastal protection measures; and
- research to improve and develop technologies to advance research in these other two areas.

Highlights

Since understanding the mechanics of sediment movement is necessary for understanding and dealing with nearly all coastal problems, Sea Grant research has focused on this area. In fact, research in this area includes as many projects as the other two combined. A few examples show the diversity:

Small inlets—particularly those without dredged channels or jetties—stop sediment transport. Understanding this process is critical to managing coastal regions. Researchers at the Virginia and Massachusetts Sea Grant programs are studying the physical characteristics of small inlets in the Chesapeake Bay system and Cape Cod. The same programs are studying how fluid and sediment interact at the bed in the nearshore and on the continental shelf. In Delaware, scientists studying coastal history have found evidence that over the past century Delaware's barrier beaches have diminished in size and volume. Further experimental confirmation may lead to profound changes in traditional coastal management. Most significant in this research category has been the Nearshore Sediment Transport Study.

The economic impact of nearshore sediment transport is enormous: worldwide costs for coastal dredging and shoreline protection rise into the billions of dollars. But existing models (mathematical formulas) for predicting sediment movements in the nearshore along straight coastlines had been derived experimentally from sparse measurement of both the causing factors (waves and currents) and the reactions (sediment motions). Not only were the basic measurements deficient, but the models failed to account for factors like wind stress, sediment size, bottom slope, and variations in waves and currents along the coast. Clearly, we need improved predictive tools. It became apparent that to have several researchers working together in a coordinated series of field experiments over a span of several years using arrays of large numbers of instruments was the preferred alternative.

Understanding the mechanics of sediment movement is necessary for understanding and dealing with nearly all coastal problems.

Floating tire breakwaters have proved an effective low-cost method of protecting shoreline properties from wave damage.

In 1977 the Office of Sea Grant reviewed, accepted, and began funding the Nearshore Sediment Transport Study (NSTS).

The major objective of this program was to produce improved engineering models for predicting the motion of sediment along straight coastlines under the action of waves and currents in the nearshore zone. These would depend upon a few affordable measurements or observations and could be simply employed without computers.

The research was carried out by ten researchers from five universities or institutes and two government agencies. Three significant field experiments were carried out on two coasts. As many as 60 people and 100 instruments were involved simultaneously in field experiments. Four workshops informed the community of the program's progress. (Available to the community, at cost of repro-

In 1977 Sea Grant began the Nearshore Sediment Transport Study to produce improved engineering models for predicting the motion of sediment.

duction, for use in continued research are reports of the experiments and data, from NOAA, National Oceanographic Data Center, Code D781, 2001 Wisconsin Avenue, N.W., Washington, D.C. 20235.) The NSTS was funded from appropriations over a period of five fiscal years at a total of approximately $4 million; a portion of a sixth year was required for the preparation of this final report.

A number of other, smaller, projects are worthy of mention. Two projects look at the way water and sediment move. These have relied on data provided by the National Ocean Survey (NOS), the group which makes vertical charts and prints the tide tables used by boaters. On the Atlantic seaboard, researchers from New Jersey are finishing a model of the Hudson-Raritan estuary system; while on the Gulf coast, researchers from the Mississippi-Alabama program are upgrading existing mathematical models describing water motion in Mobile Bay and Mississippi Sound to account for river discharges.

Sea Grant has also been active in research on coastal protection. Past studies have looked at the use of natural processes and vegetation to build and stabilize coastal regions. Sea Grant researchers have answered key questions about shoreline protection and developed a body of knowledge about kinds of plants, for example, when and how to plant them and maintain them. Sea Grant's marine advisory staff has run workshops and produced instructional manuals on coastal protection.

Sea Grant has directed much attention to engineering structures. For example, UCLA engineers are developing criteria for choosing the best methods and materials for building breakwaters. Bulkheads, another common coastal protection structure, often cause erosion downdrift of the coastal sector they protect. Sea Grant engineers in South Carolina are initiating a lab modeling program that will evaluate different bulkhead designs to find one that minimizes downdrift shore erosion.

One of the big impediments to understanding the lifting of sediment from the bed into the overlying water (entrainment) and subsequent transport of sediment particles is the difficulty of tracking and measuring water motion near the seabed. Sea Grant has looked at improving the ways we measure currents that entrain and move sediment. At Woods Hole Oceanographic Institute engineers and scientists have designed, built, and tested in the field a laser velocimeter that measures water's speed at a point in the very narrow layer where water meets sediment. Another project is focused on development of a LORAN-C drifting-buoy-telemetering current meter system for investigating coastal circulation currents, like those moving along such large segments of the coast as Georges Bank. A prototype has been built and tested, and scientists have found ways to improve the design. An Ohio engineer is developing an ultrasonic transducer that determines the concentration and grain sizes of sediment on the turbulent ocean floor. Scientists in the Washington program have developed, and successfully tested in the field, a device to measure the concentrations of sediment suspended in the water. Called the optical backscatter sensor (OBS), the device, when calibrated with "ambient" sediment, provides an optical response converted to electrical charge which relates concentration to output signal. It is unaffected by bubbles which are common in the nearshore waters and can be built in different sizes to measure suspended sediment at different scales of motion.

During the biennium, Sea Grant funded 57 projects at 21 institutions—a total of $4.7 million in Federal money and $1.4 million in matching contributions from state, local, private, and other non-Federal sources.

NATIONAL PROJECTS

Congress added special provisions for addressing problems of national scope.

Congress reviewed the first ten years of Sea Grant in 1976 and changed the original legislation to include special provisions for addressing problems of national scope. Since some states had often been unwilling to use their limited matching funds for anything but regionally oriented projects, matching requirements may now be waived when addressing selected national needs.

Congress appropriated $1 million per year to fund "national projects" without the requirement for matching funds. The Secretary of Commerce identified national needs that may be addressed by "national projects." Sea Grant is currently supporting research directed at three of these needs: problems of coastal sand movement, corrosion, and radioactive wastes.

Sand Movement

The complex processes that cause sediment movement and erosion have perplexed modelers for years. The Nearshore Sediment Transport Study (NSTS) began in 1976 to improve scientists' capability to develop and test engineering models that can predict sand movement both along the shoreline and back and forth between shore and deeper water. The combined forces of wind, waves, and currents keep the sand forming the beach and the nearshore ocean bottom in almost continuous motion. The cumulative effects of these motions are easily recognized. They result in damaging erosion of the beach and wave attack on the areas behind it, in accumulation of sediment, in formation and movement of sand bars offshore and at river mouths, and in clogging of harbors and channels.

The turbulent water stirred up by waves breaking close to shore is where the suspended sand concentration is highest. Since this is a difficult place to keep measuring instruments for very long, little field data existed.

Accordingly, a team of investigators from California, Delaware, Washington, and Massachusetts embarked on an unprecedented measurement program of well-instrumented, large-scale field experiments. So far, two have been completed—one at Torrey Pines Beach in San Diego and the other at Leadbetter Beach in Santa Barbara—giving us the best data ever collected on the dynamics in the surf zone. A smaller-scale experiment at Rudee Inlet, Virginia, can help scientists develop more reliable sandtransport engineering models for use in designing harbors, restoring beaches, dredging channels, and erecting protective structures.

Nearly $4 million will have been expended on this project.

Corrosion

The second national project, a three-year, $440,000 per year research effort begun in 1981, tackles a perennial marine problem: corrosion. It is estimated that corrosion of marine structures and vessels costs the United States more than $10 billion annually. A group of university scientists from Delaware, Florida, and Massachusetts have teamed up with industry researchers from the LaQue Center in North Carolina to learn how environmental factors affect corrosion rates and the buildup of calcareous deposits on metals exposed in the marine environment. At present, structural design and. corrosion protection practices are based on trial and error rather than on understanding of the electrochemical processes.

Waste Disposal

Anticipating pressures to bury radioactive wastes in certain deep ocean sediments, a third national project began in 1980 by investigators from the Woods Hole Oceanographic Institute with support from both Sea Grant and NOAA's Office of Marine Pollution Assessment. Scheduled to continue through 1984 at a total cost of $500,000, the research focuses on physical and chemical factors that govern how marine sediments interact with radioactive substances that have reached the seafloor from dumping or from atmospheric fallout.

INTERNATIONAL PROGRAM

On this water planet of ours, the United States is among a handful of coastal nations that have been able to dedicate a significant portion of their scientific resources to understanding the seas that border them. Yet scores of nations, while possessing potentially rich and economically significant marine resources, lack the scientific and technical expertise to understand, to develop, and to protect them for the benefit of their people.

Sea Grant is recognized as a very successful experiment in pursuing such understanding in a comprehensive manner that fosters development and conservation of such resources. In 1976 Congress expanded the Sea Grant legislation to include international projects that would enhance marine science in developing nations.

Through projects at Sea Grant institutions in this country the International Program builds marine science and technology capability at cooperating institutions in developing nations, thus promoting a two-way exchange of data, information, and scientific talent useful to both parties. Sea Grant International Projects have been conducted in every part of the developing world with the exception of tropical Africa. In each case the projects have been built upon existing relationships between U.S. universities and counterpart institutions in the developing nation.

During 1980, the Sea Grant International Program supported projects in Colombia, Costa Rica, India, Mexico, and South Pacific island nations, totaling $909,400. Of these, four were extensions of continuing projects.

In 1981, however, budgetary constraints brought a shift in the International Program's focus to fulfilling commitments to continuing projects. Two Sea Grant institutions received grants totaling $312,400 to complete their projects in Chile and Malaysia.

Thus, during the biennium, three international projects were completed and two were extended using the remainder of funds originally awarded to ensure satisfactory conclusion. Sea Grant's success with these projects demonstrates that the inherent difficulties associated with international programs—distance, uncertain communications, travel costs, cultural barriers—can be overcome, and that the objectives of the Sea Grant International Program are being met.

Highlights

Chile. The New York Sea Grant Institute and the University of Concepcion in Chile have cooperated in strengthening marine research and education capabilities at the University. Eight Chilean scientists studied at the State University of New York's Marine Sciences Research Center at Stony Brook, New York. Nine U.S. scientists spent several months in Chile, providing short courses and technical training and guiding research projects. In addition to Sea Grant funding, the project received support from the Organization of American States, the Tinker Foundation, the National Science Foundation, and the University of Concepcion itself. The coinvestigators on this project attribute its success in part to the existence of a formal memorandum of understanding between the two universities, flexibility by sponsors, and an earlier Fulbright scholarship which made it possible for the lead Chilean investigator to study marine biology at Stony Brook.

Colombia. In 1977, researchers from the University of Miami went to Colombia to examine the increasing degradation of Cartagena Bay due to pollution by mercury and chlorinated hydrocarbons. As the work progressed, it became clear that local studies lacked the coordinated approach required to develop a management plan for the bay. However, Colombian scientists, technicians, and university students were dedi-

Through projects at Sea Grant institutions in this country the International Program builds marine science and technology capability at cooperating institutions in developing nations.

cated to protecting and preserving the bay environment and its resources.

Therefore, a Sea Grant international project was started with two chief objectives: to provide a series of lectures and seminars on the principles of multidisciplinary marine research, and to provide scientists and students with on-the-job experience in the planning, execution, and coordination of field and laboratory research to assemble the information needed for management. These objectives were accomplished with participation by the Colombian Institute for the Development of Renewable Natural Resources (INDERENA), the Colombian Navy's Center for Oceanographic and Hydrographic Research (CIOH), the Cartagena campus of Jorge Tadeo Lozano University, and other Colombian universities. About 48 students and professional scientists received some amount of training from this project and several students are using the research results for their theses. The project is expected to promote further cooperation between U.S. and Colombian marine scientists.

Mexico. An international project between the University of California and several Mexican academic institutions is part of a long-term effort to establish parity among all these parties in the field of marine research and education. The objectives of the project are to train a self-supporting, self-perpetuating cadre of marine research technicians for the Mexican scientific community, to acquire marine science publications, to provide short courses for faculty and staff members, and to make available short-term, intensive training through summer courses in the United States. As a result of this cooperation, two oceanologists from the Instituto Nacional de Pesca were trained in the calibration and operation of deep-sea thermometers; 16 students from the Escuela Superior de Ciencias Marinas and several graduates from the Centro e Investigaciones Ciencias y Education Superior de Ensenada attended a workshop on primary productivity measurement; a researcher at the National Marine Fisheries Service Southwest Fisheries Center taught ichthyoplankton identification at the Instituto Nacional de Pesca; thousands of bound volumes were provided with the assistance of the "People to People" Program; hydrographic data were shared; a marine technicians' handbook was translated into Spanish; and one of the investigators helped design a Mexican research vessel. And perhaps most important, colleagues on both sides of the border are now sharing their ideas at bilingual scientific meetings.

Costa Rica. A University of Delaware project trains Universidad de Costa Rica students, faculty members, and staff in a number of scientific and technical areas associated with the study of tropical ecosystems. With few exceptions, the training has been conducted as part of actual research projects rather than in the classroom. In a related but separately funded activity, two Costa Rican scientists have earned advanced degrees at the University of Delaware and returned to Costa Rica to participate in the joint research. The general objectives of the project are to determine baseline ecological conditions in the Gulf of Nicoya and to aid in the management of fish resources in the region. Most of the work is done from the University of Delaware research vessel *Skimmer* stationed in the Gulf of Nicoya. Chemical studies have resulted in the definition of chemical conditions in the upper and lower Gulf; physical studies have expanded on earlier work done in the 1950s by the Inter-American Tuna Commission; and biological work allowed quantification of benthic invertebrates and fishes in over 20 sampling areas in the Gulf. In addition to Sea Grant support, this project has received financial support from the Organization of American States and the Universidad de Costa Rica.

South Pacific. An international project between the University of Hawaii and the University of the South Pacific is helping to train marine extension agents for the eleven small Pacific island nations served by the University of the South Pacific. A seminar/workshop on the use and management of inshore marine resources was held at Fiji in November 1979. Marine extension agents from Fiji, Tonga, and the Solomon Islands have been trained at the University of Hawaii. Each received broad exposure to marine studies, but each one also concentrated on a particular area—snapper fishery management, gear technology, or marine economics. The project also makes frequent use of the PEACESAT satellite communication system for inter-island conferences and for transmission of marine information throughout the eleven nations.

OCEAN ENGINEERING

The National Picture

Engineering is simply the application of knowledge from mathematics, the physical sciences, and biological sciences to man's use of the earth's resources. Sea Grant has been working on developing and applying engineering technologies to the ocean.

Ocean engineering is more difficult than land engineering, because so many factors make ocean work more complicated, more expensive, and more dangerous than working on land. We also know much less about the ocean than about land. But as the resources of the future lie in ocean environments, so the technologies of the future must accommodate.

Technologies grow and change in our competitive world. If the United States doesn't keep current in ocean engineering, other countries will surpass us. But someone must support new work, develop new methods, and apply this new knowledge.

Sea Grant draws on resources at the academic campuses—on the engineers doing the basic research—for the development of technologies. And through its extension program, Sea Grant continues with the application of these methods.

Generally, Sea Grant leaves state-of-the-art design for the practicing engineers of the private sector. In less developed areas, though, like fisheries or aquaculture, where the industry has no access to technologies and few resources for keeping up with the state-of-the-art, Sea Grant has found it can aid these industries and at the same time give engineering colleges experience with real design problems.

Most of the engineering work supported by Sea Grant, however, is research, for example, development of new design methods or knowledge applicable to difficult new problem situations.

Nationally, Sea Grant has focused on marine corrosion, reducing the hazards of underwater work, and ice engineering.

So many factors make ocean engineering more complicated, more expensive, and more dangerous than working on land.

Highlights

The U.S. fisheries industry is suffering from increased harvesting costs based on fuel and interest rates. Sea Grant is seeking ways to reduce the costs to fishermen:

- Looking for ways that shrimp fishermen can run their vessels more economically, the Mississippi-Alabama Sea Grant Consortium looked at their fuel use. These results will guide Sea Grant in future research on efficient fuel use.
- Researchers at MIT and the University of South Florida are investigating the possibility of fitting fishing vessels with sails, and finding the best and safest way to use sails as auxiliary power.
- Oregon State University researchers found a correlation between some underwater noises made by malfunctioning shipboard equipment

and poor albacore fishing. This finding may improve both ship maintenance and fishing.

Underwater inspection and repair is a high-risk job for divers. When working on multimillion-dollar deep-sea structures—where risks are great and expenses are high—repair and inspection must be quick and accurate. In the most hazardous situations, robots may replace human divers. Sea Grant engineers are working on how to control and communicate with these robots. Tests of mechanical remote manipulator devices at MIT show what combinations of human and computer control the devices need to work under severe communication constraints. Other scientists at MIT are learning how to send acoustic messages through the ocean environment by applying new communications theory and digital systems that combine tones into "chords." These chords can carry commands and receive information through hundreds, even thousands, of feet of water without a fixed connection. The researchers are also exploring ways to create deep-sea receiving stations using fiber optics to reduce time delays and allow clearer audio and visual communication.

In a related study, California Sea Grant investigators are exploring the possibility of combining the two-dimensional visual image from television with the depth perception qualities of a sonar signal to provide a three-dimensional "picture."

The best gauge of a new technology's success is its use. Industrial interest in the early research stages is the best predictor of use. In this country there is little collaboration on research goals among academic researchers on different campuses, the industries involved, and Federal agencies. Sea Grant in Massachusetts has set up the Marine Industry Advisory Service (MIDAS) at MIT to develop relationships between industrial scientists and engineers and university researchers. MIDAS has shown that industry can become interested in advising, monitoring, and collaborating in research at academic institutions if the program deals with the real problems of engineering; the researchers can handle the problems; and they can sustain effort long enough to solve the problems.

No U.S. institution meets all these standards. Although many universities have curricula in ocean engineering, no stable, multidisciplinary, problem-oriented research groups exist in ocean technology that can provide a research "Center for Ocean Technology." In Great Britain and Norway, many such centers were created in the last decade in conjunction with universities.

American universities began to cooperate with industry in ocean engineering in 1980. Eight researchers from five universities and one industrial research laboratory developed a three-year study of marine corrosion problems—for example, the relation between calcareous deposits and cathodic protection and the corrosion of aluminum and stainless alloys in seawater. The industrial research lab conducts experimental work and provides an industry-university link which is further strengthened by an industrial advisory panel that guides researchers in priorities. Prestigious researchers from many phases of industry have joined the panel.

When oil spills, there is little time for selecting the most efficient cleanup equipment, and estimating the costs of cleanup, impact, and damage. Sea Grant ocean engineering professors led an industry-academic research team organized through the MIT Sea Grant Program to develop two problem-solving oil spill models. One evaluates alternative cleanup strategies; the other locates emergency equipment for small- to moderate-size spills. The Navy and the Coast Guard are currently testing these valuable tools, which allow a comparison between the costs of cleanup and the costs of environmental damage. The model provides a basis for decision and action in case of an oil spill.

The National Sea Grant College Program supported 229 ocean engineering projects in 22 programs with total Federal funding of $8 million in the biennium. The 229 projects include 26 supported by pass-through funds from other Federal agencies. The objective of these studies is to develop the technologies we need for better development, management, and use of marine resources.

MARINE ECONOMICS

Sea Grant has turned the Nation's attention to the economic importance of the resources of our oceans and Great Lakes.

How can the resources of our oceans and Great Lakes—our fisheries, minerals, energy, harbors, and coastal lands—best contribute to our economic welfare? To answer this basic question, Sea Grant supports marine economists who study availability and use of resources, the economic factors that affect resource use, and the analytic approaches that might enable better development and management.

Economics can be described as the study of how, in our quest for economic well-being, we make choices among competing claims for scarce resources. The Sea Grant endeavor—turning the Nation's attention to the economic importance of our ocean and Great Lakes resources—extends the economist's work into the marine area. Sea Grant economists, both in research and advisory services, are involved with resource issues in fisheries management and development, aquaculture, marine education, coastal zone management, marine minerals and energy, marine transportation, and marine pollution.

Highlights

In the last five years, Sea Grant has responded to the increasing need for economic information to manage our Nation's fisheries. Accounting for some 60 percent of the marine economics research program, fisheries management and development might be said to comprise the national focus of the Sea Grant program in marine economics.

Researchers on both the west and east coasts are studying the operations of multi-purpose fishing vessels. Because these are fitted to har-

vest different species, they allow fishermen to be more flexible in responding to seasonal and year-to-year changes in fish availability, prices, or costs. Understanding how these vessels affect harvest is important to fisheries management.

Although many economists and fisheries managers see limited entry as a way to improve the fishing industry and plans for limited entry have already been adopted for a few fisheries, most fishermen continue to oppose it. Researchers in Maine are studying the case against limited entry in order to translate the industry's opposition into an economic framework conducive to policy debate.

While the Magnuson Fisheries Conservation and Management Act of 1976 opened a new era for domestic fishermen, it has raised many questions about long-term effects on world fisheries. Economists in Washington's Sea Grant program are studying the international impacts and economic importance of international joint fishery ventures. These are the growing number of commercial undertakings where risks and benefits are shared by foreign partners. In world fisheries, such partnerships usually involve private or government interests of a host country and a foreign partner. In the United States, overseas operators are involved with domestic fishing vessels which harvest species that are not being used by the local fish processing industry. Initial study of northern Pacific joint ventures shows short-term benefits to the U.S. harvesting sector, although these ventures may slow the development of the domestic processing potential.

University of Washington economists are also studying how the new order in world fisheries relates to distant-water fishing. In this study, they are assessing the replacement of international organizations by coastal states in the management of fishery resources, the expansion of coastal fisheries, the decline of access for distant-water fishing, the energy problems, the growing costs of harvesting, the joint venture boom, and the changing patterns of world trade in fishery products.

Most fish populations consist of several age classes. Both commercial value and reproductive potential depend on age or size. For instance, yields of hard clams harvested from Long Island, New York, are classified and sold by size. Since the smallest legal size has the highest value, most clams are harvested as soon as they reach legal size. Few grow to the larger size, which has greater reproductive potential. This paradox makes it hard to determine the best harvest patterns. Economists at Cornell University are working with biologists at State University of New York at Stony Brook on a bioeconomic model of the hard clam fishery that will relate age distribution to reproductive potential and value at harvest. Preliminary results suggest

Because multi-purpose fishing vessels are fitted to harvest different species, they allow fishermen to be more flexible in responding to seasonal and year-to-year changes in fish availability, prices, or costs.

International joint fishery ventures are among the growing number of commercial undertakings where risks and benefits are shared—in these cases by foreign partners.

that large gains in net revenues could result from a management policy that recognizes that larger clams have more value in the bay where they continue reproducing than in the marketplace.

In Wisconsin, some industries and municipalities find that in order to meet new water quality standards they would need to invest in pollution abatement equipment beyond "best practicable technology." An economist and an engineer from the University of Wisconsin teamed up to find better ways to meet the water quality standards. They showed that pollution control could be achieved at the least cost if the most economically efficient treatment plants did more of the additional abatement. The Wisconsin Department of Natural Resources has adopted new discharge regulations which allow trading "rights" to dump wastes. These *transferable discharge permits* allow industrial plants or municipalities hard pressed to meet effluent restrictions to pay more efficient treatment plants to remove more wastes than required. In this way, the total amount of wastes dumped averages out to meet water quality standards, but at much lower costs. For the paper mills and towns along the lower Fox River, this innovation could save $13 million a year.

Many resource development problems are of national scope and call for an integrated effort among several institutions. Sea Grant is committed to supporting these regional and national efforts.

Markets for seafood landed by American fishermen are diverse, and so are the market impediments to expansion and development. Economists from six Sea Grant universities and the National Marine Fisheries Service undertook a major study of marketing problems facing fishermen. Their results were published in a booklet, *Marketing Alternatives for Fishermen,* and widely distributed. They discuss alternatives ranging from traditional dockside cash markets to sophisticated contracting arrangements and vertical integration, and analyze the requirements for success in each of these alternatives as well as their effects on fishermen, marketing firms, and consumers.

As part of the legislatively mandated Emergency Striped Bass Study, the U.S. Department of Commerce and the Department of the Interior were directed to conduct an economic study of the Atlantic coast striped bass fishery. Building on the continuing Sea Grant study of the Chesapeake Bay striped bass fishery, a team of economists at four Sea Grant universities is conducting a regional analysis of the impact of the striped bass sport and commercial fisheries on local economies, and of the value of the striped bass resource. This study is coordinated by the University of Maryland program, with funds from the National Marine Fisheries Service and the U.S. Fish and Wildlife Service. Two complementary Sea Grant projects are looking more closely at local socioeconomic aspects of that fishery.

New Directions

During the biennium Sea Grant identified national marine needs, pointed to opportunities, and further defined its own role. In 1981, Texas A&M Sea Grant held a workshop on setting priorities in marine economies and social sciences. Participants focused on identifying areas where economic and social research could have the greatest impact. Their efforts will provide Sea Grant with new directions in economics and the social sciences.

Dollars and Data

Of 27 Sea Grant programs, 21 support research in marine economics. The marine economics program budget has remained between 8 and 9 percent of Sea Grant's total research budget over the past three years. During this biennium, Sea Grant supported 51 marine economics research projects for a total of $1.6 million annually. Local Sea Grant institutions provided $800,000 in matching funds. These figures include five projects supported by pass-through funds from other Federal agencies, including the National Marine Fisheries Service, the Office of Marine Pollution Assessment, the Office of Minerals and Energy (all within NOAA), and the Fish and Wildlife Service, U.S. Department of the Interior.

This commitment of research resources from Sea Grant, coupled with the advisory or extension effort in economics, involves Sea Grant economists in the crucial work of developing and managing the Nation's marine resources.

SOCIAL SCIENCES

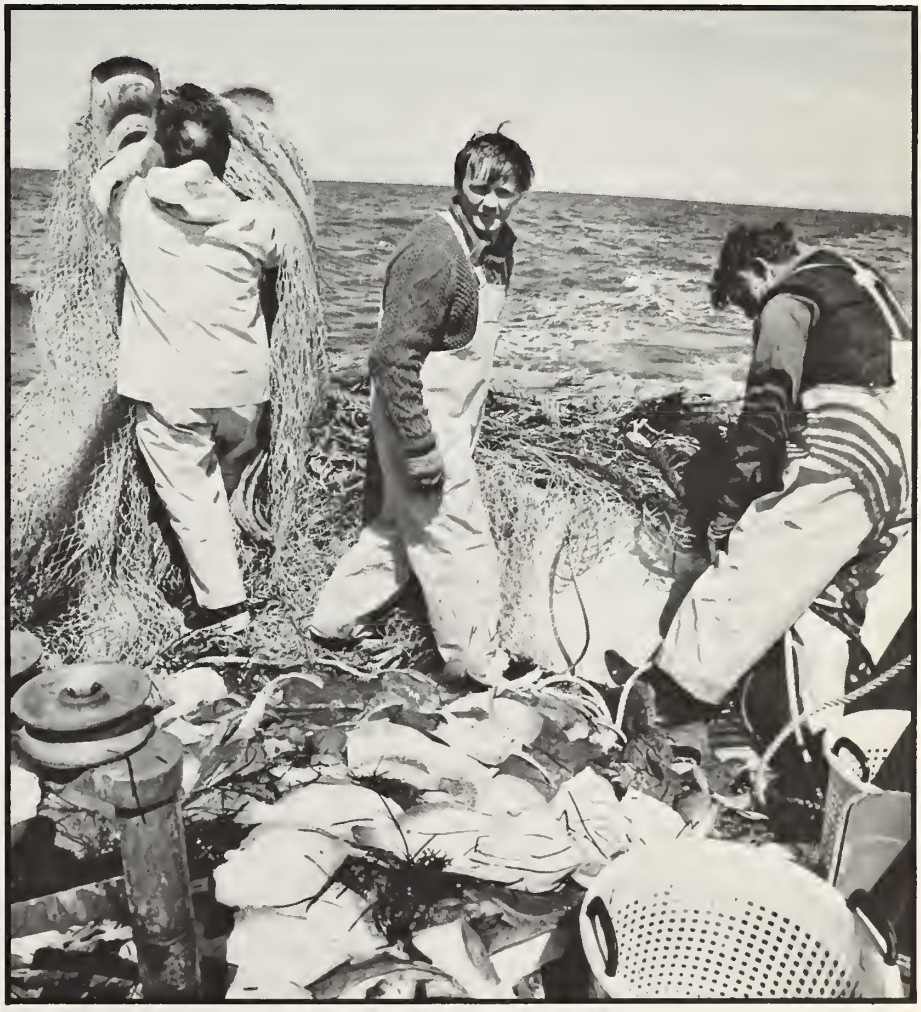
National and regional needs for social research in marine affairs have increased in direct proportion to the use, and regulation of use, of the coast.

Human activities and their consequences for the marine environment are the "specimens" studied by the anthropologists, geographers, historians, political scientists, psychologists, and sociologists working with Sea Grant. The results of this activity are as important to fishery managers, for example, as the results of biomass surveys, since it is impossible to manage a fishery without managing the fishermen.

The national and regional needs for social science research in marine affairs have increased in direct proportion to the use, and regulation of use, of the coast. The 1980 census shows a marked growth in population in the coastal regions of the United States. Access to raw materials and transshipment points make these regions attractive to industry; and the coastal environment enhances the quality of life for those who live, work, and play there. All in all, the productivity of the ocean has barely been scratched. Ocean mining and ranching are still in the early phases of development; the oil industry is still exploring. But it is the human component of these activities that is the most unpredictable, and the potential for user conflicts is increasing.

A common criticism of social scientific research is that the results are difficult to quantify. Yet as resource managers have become skilled in using the information gathered by social scientists, the benefits have increased. Patterns of use and transportation described by Sea Grant social scientists have assisted coastal county planners in developing beach access routes that work well for vacationers and residents. In the same way, information about recreational fishing has helped fishery managers in allocating resources in coastal areas. With Sea Grant support, social scientists have studied potential socioeconomic impacts of the Third United Nations Conference on the Law of the Sea, of coastal zone management, of fishery management under the Magnuson Fishery Conservation and Management Act, of the pollution of estuaries and the open sea by oil and hazardous chemicals, and of the location of port facilities, to name but a few subject areas.

To provide a focus for future work, and to identify issues of national or regional importance, a social science workshop was held under the sponsorship of the Sea Grant Association and the Texas A&M University Sea Grant College Program in September 1981. Participants recommended that research focus on four areas. The first of these, described as "basic themes," concerns general information on human behavior in relation to marine activity. Thus, research is



Thirty-five percent of Sea Grant's social science research has dealt with fisheries resource and management problems.

Patterns of use and transportation described by Sea Grant social scientists have assisted coastal planners in developing beach access routes that work well for vacationers and residents.

needed on the values of coastal and marine resource users, and the patterns of decision making and communication defined by those values. This information leads to sound and realistic decisions in such areas as marine resource use, development activities, and problems in coastal management.

A national concern identified by these Sea Grant researchers was the need for adequate information on the contribution of marine resources to the national economy. That calls for research into the socioeconomic impacts of population growth in coastal regions; the availability of labor for the marine sector; the impact of national and international regulations on maritime industries; managing and marketing new or exotic marine resources; and finally, the crucial area of technology transfer among industries, research institutions, and government.

A third need identified was for national research programs on the development of marine resources. Specific areas included fisheries, ports, tourism and recreation, and the socioeconomic impacts of industrial and military development. Impact mitigation and resource development drew particular emphasis.

Although coastal zone management has been a focus of Sea Grant attention since 1970, much work remains in this area for social scientists. In particular, workshop participants saw a continuing need for research on social change in coastal communities as it related to energy development, natural hazards, and fresh water supply. Environmental quality issues were seen as another major social science concern. Finally, coastal management problems are bound up with the marine policy and political institutions of local, state, and Federal governments. Research in these areas aimed at solving interinstitutional problems was seen as important.

The social sciences workshop was one step in the Sea Grant Network's program review and development process. As experience has developed over the decade of Sea Grant research, research projects have begun to deal with problems now perceived to be national in scope. Drawing on the earlier, local studies, a series of nationally networked projects is emerging. The pace of this process depends on the reliability of the data base, and thus it will be faster in some areas of social science research than in others.

Highlights

In the past two years 35 percent of Sea Grant social science research has gone into fisheries resource and management problems. Involving 19 Sea Grant programs and a total of 35 projects, this work has concentrated on issues related to the Magnuson Fishery Conservation and Management Act, recreational fishing, and user conflicts.

Public policy research is an important area for all Sea Grant programs, and 24 percent of social science research has concentrated on coastal zone management, ocean legal and institutional regimes, and the relationships among Federal, state, and local governments. Ten projects—10 percent of those funded in the past two years—have considered recreational issues other than recreational fishing. The remaining 31 projects were divided among port development, pollution impact assessment, natural disaster contingency planning, historical resources assessment, and studies of the use of marine and coastal zone resources by minority groups and native Americans.

The following cross-section gives an overview of the Sea Grant program in social sciences.

• University of California researchers are studying the social consequences of different management schemes for marine mammals and fish. The Marine Mammal Protection Act lays out a management scheme based on the concept of "optimum sustainable population," which in effect suggests that the only constraint on marine mammals should be the carrying capacity of the ecosystem. On the other hand, the Magnuson Fishery Conservation and Management Act (MFCMA) provides for the management of fisheries through the concept of "optimum yield," which can be roughly defined as that catch of fish which provides the maximum social and economic benefits to the nation consistent with maintaining a healthy fish stock. Marine mammals compete with man for fish; management under MFCMA principles is thwarted in some instances by marine mammal activities, for example, sea otters eat wild and cultivated abalone off California. The socioeconomic consequences of these two manage-

In 1981 Sea Grant invested $1,754,409 in social science research, 60.3 percent of which was provided by the Federal government. The research projects numbered 54, with an average investment of $32,487, in 19 states. In relation to the entire Sea Grant program, social science received approximately 3.5 percent of the overall funds available and, since these projects are labor intensive, the average cost per project was approximately $7,000 less than that of a natural or physical science project.

ment regimes are therefore important to Congress and to state and Federal fishery managers.

- Sea Grant at USC is also studying coastal zone planning and its potential effects on housing regulation for low- and moderate-income families. The availability of labor in coastal communities may determine the viability of the industrial base, and the cost and potential stock of housing may be a limiting factor.
- A perennial need in any form of coastal zone planning and resource management is an adequate information base. At the University of Georgia, a Sea Grant investigator has compiled a coastal demography of the State's South Atlantic counties. The information developed will be used, for example, in fishery management for that State, but the same methods are now available for other researchers and government agencies.
- Maine/New Hampshire Sea Grant is conducting a nautical survey of cultural-historical resources in the Piscataqua River Basin. In addition to adding to our knowledge of early settlement patterns in the United States, this research will help government agencies to determine special areas that may need to be set aside in case of resource development.
- Studies of local government officials' responses to the needs of citizen groups are being carried out by Sea Grant in California and Maryland. One such study concerning Chesapeake Bay development is exploring the communication webs that surround emotive issues. A California study is looking at conflicting interests in joint planning development by the Coastal Commission and local governments.
- At MIT, a Sea Grant researcher is studying the management of Boston Harbor. Results are already being communicated to local planners and citizen groups. Similarly, studies of management strategies for coastal wetlands by the University of Michigan Sea Grant Program are assisting resource managers and landowners in developing uses compatible with maintaining marshes.
- Fish piracy or communal fishing norms that break state fishing regulations have been the subject of Sea Grant studies at Rutgers University. In describing the human ecology of New Jersey fishing communities, this work has documented socioeconomic aspects of fisheries management as experienced by fishermen and managers. A practical result has been to increase the sensitivity of managers to the consequences of different strategies for fishery management, and to allow them to choose techniques that are more likely to be respected.
- Recreational fishing in Texas has been studied for several years by a team from Texas A&M Sea Grant. Information from this study has been used in the management of, for example, the redfish recreational fishery. Sea Grant researchers from Maryland, New York, and North Carolina have cooperated informally with the Texas program in the development of comparative information bases and research methods. The results are a better socioeconomic data base than could have been developed purely by local research, and opportunities for improved fishery management planning by the National Marine Fisheries Service, the U.S. Fish and Wildlife Service, and state agencies.
- Sea Grant-sponsored studies of minority groups have focused on Vietnamese fishermen in the Monterey Bay area of California, and in Texas, on Vietnamese refugees now fishing in Galveston Bay. And a Sea Grant scientist at the University of Wisconsin has examined the cultural continuity of the Afro-Americans of the Georgia Sea Islands. All three studies will provide information which can be used by local agencies and resource managers as they determine alternatives for development.

Other social science work has included a variety of topics and issues: sport fishing, transportation, pollution, socioeconomics, marketing and technology transfer.

SEAFOOD SCIENCE AND TECHNOLOGY

What makes some fish products more successful than others? Success seems to depend on quality, attractiveness, price, efficiency of production, and traditional dietary habits. Research on all these issues makes up Sea Grant's program in seafood science and technology.

Because American industry has been unsuccessful in harvesting and marketing all the exploitable fishes in domestic waters, the Fisheries Conservation and Management Act allows foreigners to fish our waters. It works like this: when American fishermen catch all the fish they are allowed to catch, according to the fisheries management councils, fishing rights within 200 miles of the U.S. coast are turned over to foreign fishermen. Even though our fishery resources are among the richest in the world, we import more than 60 percent of our own seafood; many foreign countries harvest the fish found in American waters that American consumers don't want. Clearly, enormous opportunities lie before us for expanding the American seafood industry. How well we meet these opportunities depends largely on advances in technology for handling, processing, preservation, and waste management.

Because most processing companies are too small to have research departments, and because the industry's problems are of interest to scientists, Sea Grant has devoted a significant part of its funds to research, education, and advisory services in seafood science. This includes processing aboard ship and delivery to processors. Currently, no one—neither fisherman, processor, nor retailer—is responsible for the full range of research problems that affect quality of harvested seafood.

Before there was Sea Grant, few universities emphasized seafood technology or fisheries. Since the establishment of the National Sea Grant College Program, however, the government has spurred academic interest in this field. Now most Sea Grant colleges and other academic institutions are aiding this industry. Projects fall into four categories:

- engineering and waste treatment;
- product development and by-product recovery;
- microbiological and nutritional quality; and
- handling and processing.

Engineering and Waste Treatment

People eat squid in many other countries. But while squid abounds along our coasts, it has never held much attraction for American consumers or harvesters. One reason is the cost and trouble of cleaning squid by hand—a laborious and unpleasant task. To help overcome this problem and develop our squid resources, Sea Grant researchers at the University of California designed, built, and tested a machine that cleans squid in seconds. The pilot-scale machine can be "scaled up" for industrial use.

In similar work at MIT, engineers have designed, built, and developed a machine for processing the underused shark called spiny dogfish. Made of aluminum, stainless steel, and plastic, the machine is easy to operate, clean, and maintain.

Even though our fisheries resources are among the richest in the world, we import more than 60 percent of our seafood. Many foreign countries harvest fish American consumers don't want.

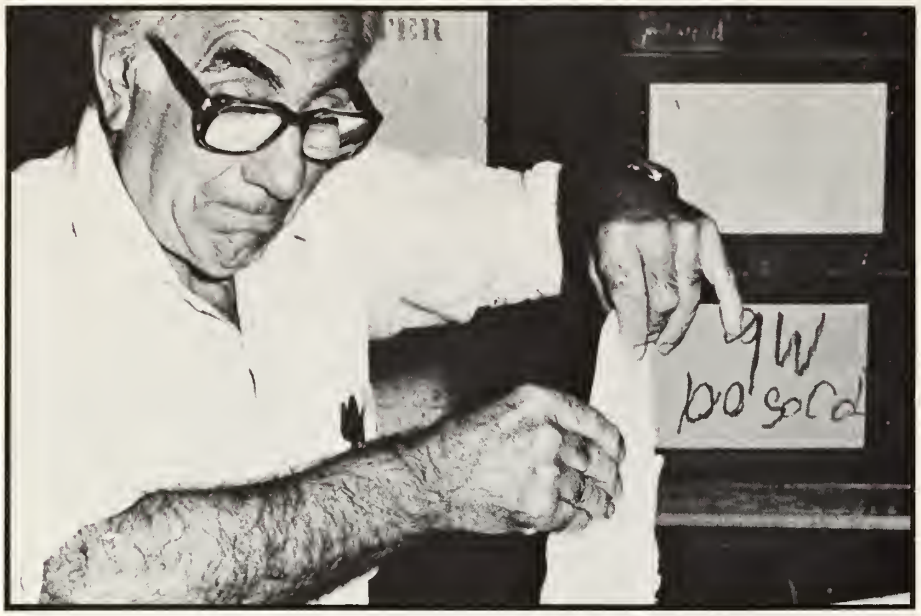
To cope with water shortages and tighter waste reduction requirements, University of Alaska engineers have developed systems for seafood processors that separate solids from liquids, conserve water, and can even recover edible by-products. Tests at one processing plant showed that using this equipment could save money. The engineers are now determining the value of using coagulants to improve the efficiency of their systems.

The University of Washington took an innovative approach with fish processing wastes ten years ago. They used enzymes and other chemicals to break down the wastes from fish processing and to convert them into usable materials. Recently, a commercial firm further developed a process based on this "total utilization concept." Using this approach they make marketable products such as fish oil, bone meal, and purified protein from finfish and shellfish wastes.

Until now, our use of enzymes for processing shellfish wastes has been limited to those used for recovering high quality proteins from finfish wastes. Investigators at the University of Alaska believe that by using enzymes made by microbes they can convert chitin—the material shells are made of—to chitosan, a polymer with many useful properties. This may be the key to improving the efficiency of shellfish processing by converting wastes into useful materials.

Product Development and By-Product Recovery

If we can make products here from our domestic species that will be eaten in other countries, we can increase consumption of our underused species and give the American fishing and seafood industries a boost. For example, it has been estimated that Nigerians eat as much as 10.5 kg (20 pounds) of seafood every year; but 43 percent is imported. They eat a lot of imported stockfish, a dried fish for stews, made from cod, haddock, or hake. Scientists at the University of Georgia are exploring ways to make stockfish for export from domestic fishes. This will require a better understanding of dehydration. Georgia investigators have already shown



Research has revealed ways to extend shelf life of fresh fish.

that a dried, minced fish product called Yu-sone used in the Far East can be produced in commercially competitive quality from stingray, mako shark, and mullet.

Researchers at Cornell University who had already made a host of new products from poultry have now developed products from underused fish and from fish processing by-products. This work has resulted not only in the successful test marketing of new products made from minced fish—including mullet and pollock sold and used like tuna—but in increased production efficiency and decreased waste disposal problems.

A lot of protein adheres to the chitin left over from processing shellfish—about 50 percent by weight. This protein is a potential feed supplement for domestic animals. Sea Grant is exploring nutritional aspects of chitin as a feed supplement. For example, Sea Grant researchers at the University of Alaska have found that crab and shrimp meals are good feed for swine. This is particularly good news in Alaska where the climate is unfavorable for growing the plants that livestock eat. This work was prompted by the great waste problems that result from processing Alaskan king crabs and the tightening regulations on waste disposal.

Researchers at the Virginia Polytechnic Institute and State University (VPISU) are also finding agricultural applications for seafood processing wastes. Disposal of wastes from menhaden, blue crabs, flounder, and porgies is a problem for Virginia processors. But leftovers from menhaden processing are good fertilizer for many crops, researchers have found. Results of their work, which is partly funded by industry, will be tested in agricultural field studies in Arkansas, Virginia, and West Virginia.

Researchers at VPISU are looking for the best combinations of seafood wastes and other underused substances that will produce nutritious and palatable silages for ruminants, and they want to ensure that this process will be more economical than producing dried meals—a process that requires great amounts of energy and contributes to air pollution.

Researchers at North Carolina State University have made a minced-fish and shrimp product that looks and tastes like shrimp. Success in developing new products like this depends on information from research on relationships between biochemical and physical properties of minced fish and textural properties of finished products. This work is part of a larger effort to develop new products for domestic and foreign markets from mechanically deboned fish. Other work there looks at ways to use domestic underused fish to make the sorts of minced fish products that are important staples in Asia.

Microbiological and Nutritional Quality

Microbiological research bears on human health and the perishability of seafood products. For example, we open and close shellfish grounds on the basis of concentrations of coliform bacteria, but we still don't know how and whether this measure of quality relates to the number of all human pathogens in shellfish. In some cases we don't know the differences and relationships between virulent and harmless bacterias, or their natural occurrences in coastal waters. Also, there is a need to improve some of the methods used in counting microorganisms in seafood and the marine environment so that decisions in management of resources can be made efficiently and with greater certainty.

When too many coliform bacteria are found in shellfish, they are unfit for eating. The waters they were harvested from are closed for fishing until the bacteria counts go down. Investigators at North Carolina State

"Total utilization" means turning wastes into marketable products. For example, enzymes can break down fish processing wastes to make fish oil, bone meal, and protein.

University have developed a new, faster, and more accurate way to count coliform bacteria in seafood. This method will produce better information on which to base the opening and closing of shellfish grounds.

South Carolina researchers are looking at the effectiveness of depuration, a natural process used to make clams and oysters from polluted waters safe for human consumption. Depuration is the shellfish's way of cleansing itself of foreign materials by pumping clean water through its body. Shellfish are simply held in clean water after harvesting, but this becomes more expensive as the shellfish must be held longer. Because copper is toxic to some bacteria and viruses, researchers believe it can be used to speed up depuration. They will test their hypothesis in lab and field experiments using different copper compounds.

Eleven cases of cholera in 1978 were linked to eating improperly cooked and stored Gulf Coast crabs. As a result, four Sea Grant programs set up a cooperative project (Florida, Louisiana, Maryland, and Oregon) to look at the kinds of viruses that caused the outbreak. The study shows that some strains of the genus *Vibrio* naturally live in the estuary; that their presence does not correlate with the presence of bacteria common to sewage; that the seafood industry was not responsible for the outbreak of cholera; and that with proper handling of shellfish, they are safe to eat.

Only certain kinds of the *V. cholerae* seem to cause disease, but these types are yet to be identified. Because no reliable method was available for isolating them, microbiologists at Louisiana State University developed one. Their innovative method uses plastic beads coated with antibodies against the disease-causing strain to separate the organisms from water. The procedure, it is expected, will prove useful for isolating specific strains of other pathogenic microorganisms, including clinically significant species.

If we can make seafood products for other countries, we can increase consumption of our underused species and give the U.S. economy a boost.

Studies are under way at the University of West Florida on the effects of storage and handling on concentration of human pathogens in shellfish. These have defined the bacterial composition of clams and oysters, and shown that the microbes that live in oysters are more sensitive to storage conditions than those of clams, and determined the effects of storage time and temperature on quality.

Handling and Processing

Food scientists at Oregon State University developed new ways to handle Pacific shrimp during the period before they are peeled and processed. The procedures, involving use of preprocessing solutions and temperature control, are simple and increase the yield of processed shrimp by about 20 percent. These methods have already been applied in several plants in Oregon. If processors in Oregon alone adopted these procedures, the yearly savings in currently wasted shrimp would exceed $10 million.

Researchers at Cornell University have extended shelflife of fresh fish. They noted that fish—no matter how well they were iced—could keep an excellent rating for just six days, a good rating for no longer than ten. If the fish were blanched first though—for just two seconds in water at 90°F—they held their excellent rating longer. While blanching destroys bacteria and bacterial enzymes in fish, it does not provide enough heat to penetrate the skin or affect the appearance of the fish. Researchers suggested that fishermen, even before bringing the fish ashore, could heat the water for blanching economically by using the ship's stack exhaust.

Studies at the University of California have shown that packaging fish in mixtures of carbon dioxide and air inhibits the growth of major aerobic age bacteria that cause spoilage. This kind of treatment is effective in maintaining the quality of fresh Pacific red snapper. Researchers continue their work to find the best proportions of gases to preserve fish safely.

Looking Ahead

Sea Grant researchers in the future will continue to address the wide range of problems that confront the seafood processing industry and diminish its productivity. A significant part of their effort will also focus on the opportunities for marketing underused species in foreign markets and for increasing the share of American products in domestic markets. Considerable work is also still required to resolve microbiological hazards that inhibit use of seafood. Paralytic shellfish poisoning (PSP) and ciquatera are two such problems that restrict the use of major resources in certain areas—PSP in Alaska, for example, and ciquatera in Puerto Rico and other tropical areas.

Sea Grant has supported much work on development of new products for various markets.

SEA GRANT MARINE ADVISORY SERVICE

Sea Grant's Marine Advisory Service is educating marine audiences, conveying their needs to researchers and managers, and disseminating useful research findings.

The National Picture

The Marine Advisory Service (MAS) is the dynamic outreach arm of the Sea Grant Program. As Sea Grant has evolved, so has the advisory service concept. The MAS function includes educating marine audiences, conveying their needs to researchers and managers, and disseminating useful research findings. Methods include publications, conferences and seminars, mass media, and extension services.

Presently, Sea Grant supports 30 MAS programs, 20 of which are aligned with Cooperative Extension. The MAS has a staff of about 300. In addition, there are three formal regional Sea Grant Advisory programs that coordinate efforts in the Pacific (PASGAP), New England (NEMAS), and the Great Lakes (GLAS), as well as informal coordination mechanisms in the mid-Atlantic, southeast, and Gulf regions.

Although MAS programs vary considerably in size, organization, and administration, they are similar in philosophy and methods. These programs seek to address the needs of identified audiences largely through person-to-person (for example, on the waterfront) communication.

The MAS programs use "advisory councils," staffed by individuals who are recognized as leaders in the community and who can reach a large audience of resource users, to determine the needs of the state and region. In many cases, each MAS agent has his or her own advisory council.

Although job classifications are not

standardized, advisory programs include "specialists" and "field agents." Specialists are responsible for particular subject areas on the statewide level, with varying degrees of field contact. Field agents deal with more diverse subject areas, are primarily given geographic responsibility, are located in local communities, and cooperate with specialists when particular expertise is needed. Currently, MAS staff tend to be "agent/specialists"—individuals with both geographic responsibility and special expertise.

Cooperation between MAS personnel and academic researchers is a key element of a Sea Grant program. With more and more scientists turning to advisory people for assistance—and vice versa—the "feedback loop" is becoming prominent in MAS function. At the same time, both specialists and field agents are encouraged to make use of whatever technical or informational resources they need, both within and outside their organizations, to help their audiences.

Even though 90% of the population of Alaska lives on the coasts, because waters are so cold, most residents don't know how to swim. MAS specialist demonstrates safety attire for cold waters.

Highlights

Fisheries and seafood technology. A good deal of MAS time is spent on fisheries and seafood technology, and the areas of activity are many and diverse. In Rhode Island, for example, more than 10,000 commercial fishermen benefit from the MAS program's information and technical assistance. Information on such topics as fishing gear, fishing methods, fisheries development, financial assistance programs, export markets, fisheries management, and fisheries research has been extended through publications, newsletters, workshops, mass media, and individual consultation.

Particular attention is being paid to: 1) gear development, 2) onboard and onshore processing and marketing, 3) financing and business management, and 4) enhancing fishing efficiency through climatic and oceanographic satellite data.

Linking the most efficient fishing gear to a particular resource, geographic location, and vessel type is the most important technological need for the harvesting sector in developing fisheries. In practice, this need breaks down into identifying, describing, and demonstrating applicable fishing methods. Depending on the fishery and its location, the MAS tailors program efforts to existing problems. For example, on the northeast coast, fishermen are being taught to use mid-water pair-trawling for herring. A cost and revenue study for one state, based on last winter's efforts, found that the total net gain per fishing vessel that used this technique was $27,300, and for all the vessels, $491,400. In the southeast, the plumb-staff-beam-trawl is presently being demonstrated to shrimp fishermen as a more fuel-efficient alternative to standard otter-trawl gear. The assembling, repairing, maintaining, and operating of the latest fishing gear, whether on a large or small scale, is a major part of the MAS effort.

As market horizons expand and more seafood products are introduced, processing technology will become critical. The MAS, aware of this fact, disseminates the newest technology, introduces new packaging forms, and calls attention to uses for new species. Fishermen are also being advised on the location of markets, transportation options, quality control, financial alternatives, buyer quality standards, processing permit requirements, and many other considerations.

Financing and business management skills are becoming increasingly important to fishermen, and the MAS recognizes that fishermen, as well as financiers, need to be educated. On the west coast, commercial fishermen, accountants, and loan officers received financial advice at four MAS workshops held in cooperation with the National Marine Fisheries Service. One important

In Rhode Island alone more than 10,000 commercial fishermen benefit from MAS information.

project was MAS participation as a member and technical leader to the Fishermen's Tax Guide Committee, a joint Sea Grant–Internal Revenue Service effort. A guide was later distributed to the Nation's fishing industry through the MAS network.

Recreational, commercial, charter boat, and head boat fishing industries are benefiting from information made available to them through the MAS with cooperation of the National Weather Service and its satellite data. This information enables users to make better decisions on when and where to fish, helping them save time and energy.

In addition, several Sea Grant programs have worked on conversion from Loran A to Loran C, and the MAS is presently working, in cooperation with the Coast Guard, to provide a smooth transition to the new system for the fishermen. The MAS is also working with NOAA's National Ocean Survey and the fishing industry to produce information for navigation.

Seafood technology is a large part of the fisheries effort. For the seafood industry, the MAS provides information on sanitation, quality control, improved processing and packaging methods, water conservation, plant safety, and waste management; and for consumers, information on nutrition, food safety, and home food preparation. In addition, the MAS is concentrating on underused species product development, waste product development (using such materials as crab shells or groundfish carcasses), and modified atmospheric storage of seafood.

The MAS recognizes that seafood processors are continuously faced with unpredictable problems that can disrupt the entire industry. For example, during the cholera outbreak and polychlorophenyl (PCP) spill in the Mississippi Gulf outlet and the paralytic shellfish poisoning (PSP) outbreak on the northeast and west coasts, the MAS mobilized to warn the marine populace, from fishermen to consumers, of the health dangers involved. In all cases, the MAS worked with health authorities and commercial shellfish producers, not only to publicize current threats but to develop an improved surveillance and educational program for the future.

Aquaculture. The amount of MAS resources devoted to aquaculture varies from region to region, depending on whether aquaculture industries and possibilities exist. Sea Grant programs have studied the aquaculture of finfish, shellfish, and plantlife, and results of this research, as well as of non-Sea Grant research, have been distributed to the aquaculture industry through personal contacts, publications, news releases, radio and TV programs, and newsletters. Currently, as the culture of various aquatic species becomes more feasible, requests for information are increasing. For example, in the Gulf the possibilities of culturing such diverse animals as penaeid shrimp, oysters, and alligators are being studied. In the Great Lakes, the commercial fishing industry has expressed interest in aquaculture as a means to replenish greatly diminished fishery stocks. The MAS has provided information and held seminars on these topics and is attempting to disseminate one Sea Grant project that is pioneering the cryopreservation of salmonid sperm and eggs, a technique that will enhance hatchery production of these commercially and recreationally valuable fish.

Marine recreation. Marine recreation is an important MAS area, especially marinas and cold-water survival. In the Great Lakes where marina operation is big business, the MAS has been particularly effective in aiding marina operators and recreation industry managers on cost savings; energy savings; tourism management techniques; development, design, and planning of waterfront access facilities; and ice damage.

Cold-water survival is important not only for recreation but for anyone who uses the marine or Great Lakes environment—divers, scientists, fishermen, and so on. Education of such users as well as of medical personnel, which has drawn heavily on Sea Grant research on hypothermia, has saved many lives. In many

Federal Sea Grant support of the Marine Advisory Service for 1981 totaled $11.9 million, with an additional $8 million in local matching funds. This accounts for about 30 percent of Sea Grant's funds and effort.

cases the MAS has worked with manufacturers to redesign survival equipment; it has given seminars to such groups as the Coast Guard, the Navy, state agencies, maritime academies, the commercial fishing industry, and the U.S. Olympic sailing team.

Marine education. Every Sea Grant MAS program has a marine education component. Educating the resource user—from fisherman to port developer—is one of the MAS's main objectives. Among many unique projects is the development of a course in marine safety for lifeguards and one for marina personnel. In the 20 programs in or aligned with Cooperative Extension, the talents of the MAS are made use of by 4-H groups. Other programs extend marine education to places like "sea camps" and aquariums.

Coastal engineering and resource development. Coastal engineering and resource development, along with port development and transportation, are becoming major areas. The MAS brings together the right individuals or agencies to help evaluate the impacts of dredging, filling, and construction; ocean shore development constraints and protection techniques; harbor construction; estuarine use and restoration policies; and erosion—presently the area of greatest focus. The MAS has been active in teaching shoreline property owners to make informed decisions about purchasing and protecting property, and in informing landowners, marine contractors, marina operators, and government agencies about selecting and using the right marine construction materials. The MAS and the National Weather Service have also cooperated in a large-scale effort on disaster preparedness and hurricane awareness.

Pollution. Pollution is a small but important area of activity, especially in the Great Lakes states where microcontaminants such as PCBs and dioxins have been found in high quantities in many species of fish.

High public and industry interest in this area has led to an expanded, high-priority effort to provide more information. Commercial and sport fishing groups, county planners, recreation industry people, business and city officials, and university researchers are all working with the MAS to combat the toxic substance problem and to teach fishermen and consumers how to prepare fish to reduce contaminant levels.

MAS has been active in teaching shoreline property owners and others to make informed decisions.

Regionalization. Regionalization of the MAS has four advantages: 1) it provides a better mechanism for dissemination 2) the possibilities for networking research projects will be greater 3) cooperation among the regional programs can help to identify and plan projects that have national implications, and simultaneously help to avoid unnecessary duplication, and 4) regionalization will facilitate organizing projects and exchanging information with NOAA and other federal agencies. Several formal regional programs are now in operation. The latest efforts to regionalize have concentrated on involving Sea Grant directors, MAS leaders, as well as communicators in programmatic planning.

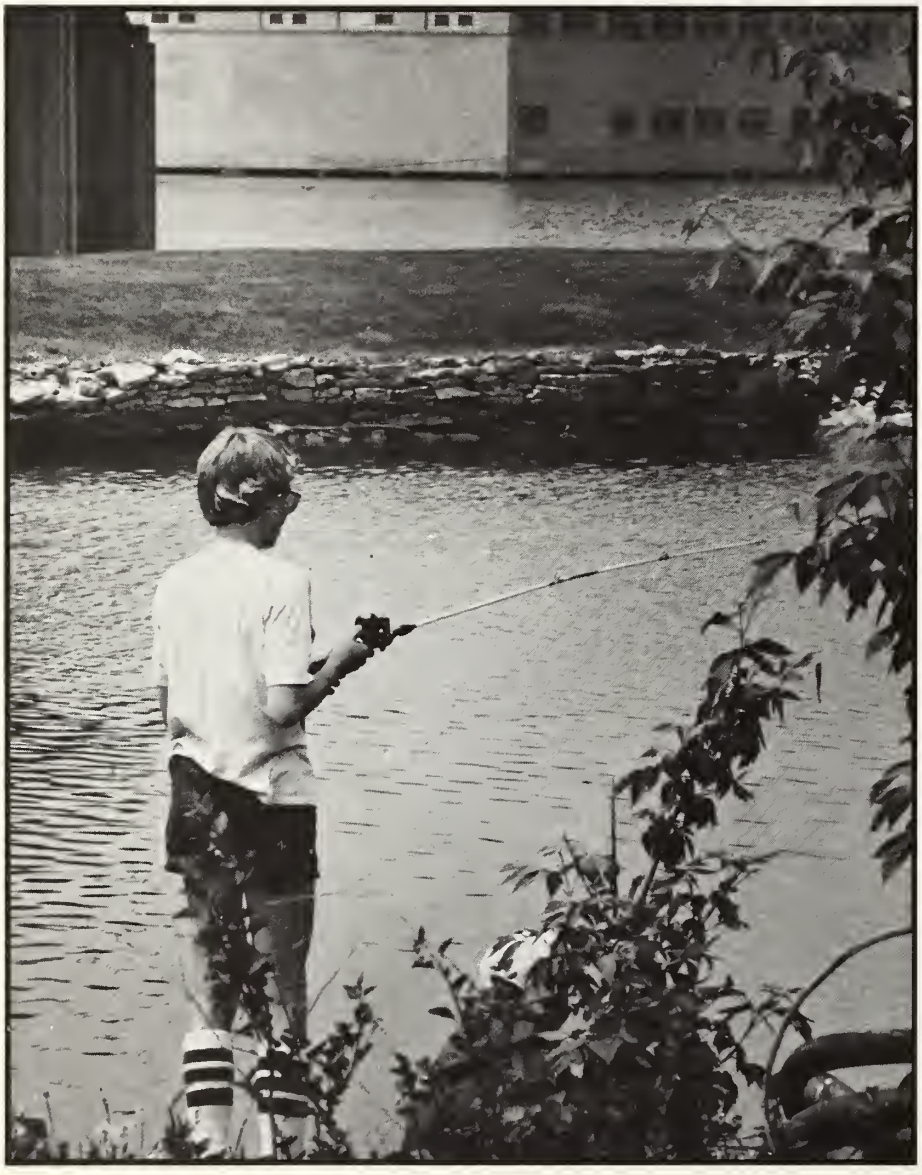
OCEAN AND COASTAL LAW

The National Picture

The Sea Grant program stands virtually alone among Federal programs as a source of sustained support for research and education relating to ocean and coastal law. Ocean and coastal law is a specialized area of law both because of the large number of local and Federal statutes specifically relating to ocean and coastal use, development, and protection of resources, and because admiralty, maritime, and other international law must be brought to bear in analyzing many ocean and coastal law questions.

Ocean and coastal law is also a developing area of the law. Many statutes in this field are relatively recent, and other solutions and implementation methods are still being pursued on local, Federal, and international levels. The fishing, shipping, ocean energy, and mining industries, as well as other recreational and industrial users, share with all levels of government a great interest in the field.

The Sea Grant program stands virtually alone among Federal programs as a source of support for ocean and coastal law research and education.



During the biennium, the ocean and coastal law program emphasized evaluation, implementation, and education of users on the fisheries and coastal zone management regimes; development of materials and curricula in ocean and coastal law; and analysis of emerging issues.

The greatest area of growth has been law-related economics, particularly to provide additional data and insight into the economic aspects of fisheries management. Sea Grant also analyzed developments in international energy and pollution (for example, dumping and storing nuclear wastes, deep seabed mining, and Antarctic mineral resource exploitation) and studied marine transportation (for example, analysis of proposed changes in shipping legislation).

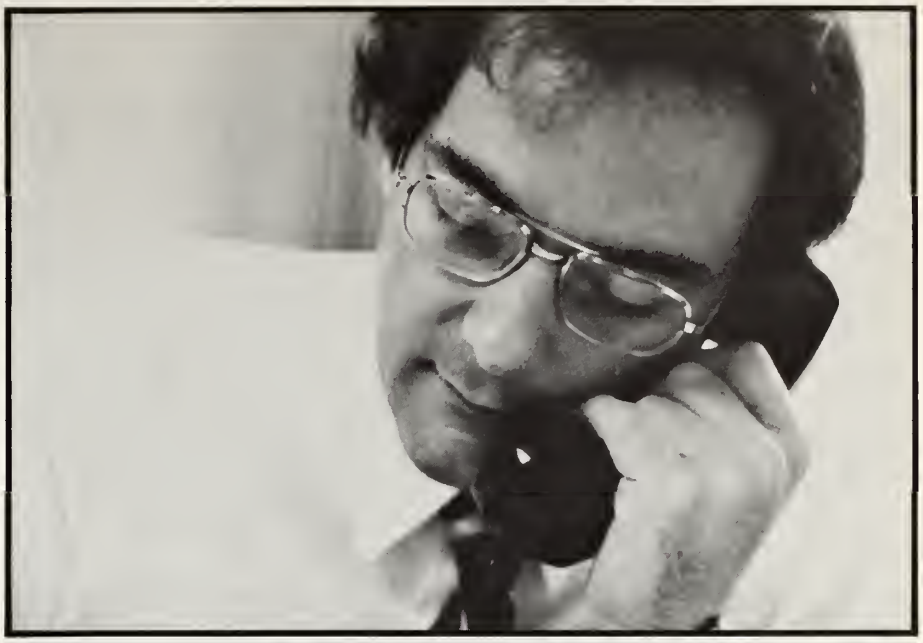
To raise awareness about ocean and coastal law, and to encourage professional interchange on these topics, Sea Grant sponsored an Ocean and Coastal Law and Policy Work-

shop in 1980. The workshop was attended by more than 50 representatives from Sea Grant institutions, Federal agencies, and congressional staff. Working groups considered issues in areas of the Law of the Sea and other international developments; ocean energy; pollution; fisheries and aquaculture; coastal zone management and protecting the habitats of marine mammals and endangered species. Attendees discussed other topics of Federal, state, and local concern, gathered their conclusions in a series of reports, and distributed these reports. The conference emphasized the continuing need for law-related studies and highlighted issues of concern to Federal, regional, and local parties affected by developments in ocean and coastal law.

Highlights

The Law of the Sea Convention. For several years the United States has participated in the United Nations' Law of the Sea negotiations. The negotiations are intended to define the rights and obligations of nations that use the seas (for example, for navigation, fisheries, environmental concerns, deep seabed mining, and other commercial activities). Sea Grant has funded a comprehensive look at the proposed treaty and provided the United Nations with information on key issues. Coastal law experts in the northwest, South Carolina, and Hawaii are studying how various proposals will affect state and federal interests.

All around the country Sea Grant has sponsored law programs to teach the lawyers of tomorrow about the importance of our fragile coastal resources.



Fishery management. Sea Grant has sponsored studies of the operations of several fishery management councils in the northeast, and on the Pacific and Gulf coasts. For example, California Sea Grant has studied conflicts with the Marine Mammal Protection Act. At Sea Grant-sponsored law programs around the country, courses and independent research focus on current fishery and coastal law issues, such as limited entry, management of anadromous fish, state and Federal relationships, and economic and legal alternatives for managing particular fisheries. Sea Grant has published reports to inform fishermen and others about developments in fisheries and coastal law.

- Sea Grant investigators in Oregon have studied the major legal and institutional obstacles to aquaculture development.
- In Michigan and in California, Sea Grant is exploring alternatives for assessing the value of coastal wetlands and learning how to manage these shrinking areas.
- In California, Georgia, and Maine, researchers are looking at how effectively local and state governments and agencies have worked together in coastal planning.
- Investigators in Hawaii are asking how current international law affects the ocean dumping and storage of nuclear wastes. Legal developments in this field, particularly with respect to the Pacific Basin, have been researched by Sea Grant investigators in Hawaii.
- Washington Sea Grant is studying how proposed changes in U.S. shipping law will affect North Pacific Ocean trade.
- And all around the country—in Washington, Oregon, New York, Maine/New Hampshire, Mississippi/Alabama, Hawaii, Rhode Island, and Louisiana—Sea Grant has sponsored law programs to teach the lawyers of tomorrow about the importance of our fragile coastal resources.

During the biennium, Sea Grant supported 86 projects related to ocean and coastal law at 21 institutions with about $2.4 million in Federal funds and $1.9 million in matching funds. Of the Federal dollars, $290,000 came from Federal programs other than Sea Grant. These figures represent a significant increase over the $1.7 million in Federal funds and $1.7 million in matching funds expended on law-related projects in 1978 and 1979.

MARINE EDUCATION AND TRAINING

The National Picture

Marine education at all levels is becoming increasingly important. There are many unfilled jobs in the marine industry for people with varying educational backgrounds. These jobs range from sail rigging (requiring vocational-technical training) to marine-oriented computer science (requiring at least undergraduate degrees and usually graduate degrees). The interest in marine resource development is growing, and more trained and educated personnel will be needed to fill more jobs. And there is a continuing need to increase children's awareness of the nation's water resources.

In the last two years, the Marine Education and Training arm of the National Sea Grant College Program has been meeting or exceeding its stated goals: "To build and maintain broad, high quality curricula for education and training of qualified professionals and technicians to meet requirements for the development and management of the nation's marine resources; continuing education opportunities for practicing professionals, technicians, and decision makers engaged in marine related activities; educational exchange programs; public education at all levels to increase public awareness and understanding of the realm of marine affairs and enjoyment of the sea."

Dollars and Data

Sea Grant spent a total of $5.6 million in education in 1980 and 1981. This commitment was matched by state, private, and other nonfederal sources at the level of $3.5 million.

Sea Grant divides its Marine Education program into several categories.

- College- and graduate-level course development. This element is directed at colleges and universities that have a need for advanced courses in the marine science engi-

Many unfilled jobs are in the marine industry, ranging from sail rigging to marine-oriented computer science.

Sea Grant is making literature produced in marine fields available to educators across the country.

neering field. Courses are highly specialized and include training for students to perform their own research. In this category, $140,000 was spent, or approximately 20 percent of the education budget.

- Research assistantships. Students well into studies leading to advanced degrees are the focus of this element. The assistantship usually provides support for thesis completion in Sea Grant-related areas of study. Approximately 27 percent of the education budget, or $1,490,000, went to this category.

- K-12 curriculum development and teacher training. In order to focus on marine awareness and K-12 curriculum resources, Sea Grant maintains a baseline of materials for use throughout the Nation's school system. This category accounts for $975,000 or approximately 17 percent of the education budget. Curriculum materials are available from the Sea Grant network and other educational resources. It is not expected that any major new efforts will be made in this area.

- Nonformal education efforts. This element divides formal and informal education. It is directed at noncertificate courses for adults who wish to continue their practical or general education. In this category $490,000 was spent or approximately 9 percent of the education budget.

- Marine technician, vocational, and prebaccalaureate training. Directed at the vocational-technical community, this element provides the opportunity for students to pursue training to the level they desire, or to go on to undergraduate studies. It also emphasizes practical training for marine technicians. Eight percent of the education budget, or $435,000, supported this program.

- Sea Grant Fellowship Program. Established under the Sea Grant Program Improvement Act of 1976, this element provides assistance to specialized students in any field of study related to ocean and coastal resources. In this category, Sea Grant dedicated $550,000 or approximately 11 percent of its education budget.

- Other education and training. Publications, art festivals, marine awareness programs, and similar activities fall into this category, which accounts for 8 percent of the education budget or $470,000.

Highlights

Through its Marine Education and Training mandate, Sea Grant is making literature produced in marine fields available to educators across the country at all levels. The Marine Education Materials System (MEMS), located at the Virginia Institute of Marine Sciences, gathers these resources into a computerized data base where they can be on-line and accessible all over the country.

The Marine Education and Training network has increased marine awareness among students from kindergarten to twelfth grade by introducing marine-related subjects into classrooms—not only science classes but social science, math, and art classes as well.

In addition, supported by Sea Grant, college professors have developed graduate and undergraduate courses in virtually all areas of marine affairs, tested those courses, and tried them out as college curricula.

INFORMATION AND AWARENESS

The National Picture

The end product of all Sea Grant endeavor is information: facts and figures, techniques and procedures that are immediately useful to those who use the seas, and ultimately beneficial to the Nation. Sea Grant information may be translated into a new piece of fishing gear or the equations necessary to design offshore structures; a business course for marine operators or biomedical extracts from sea life that promise cures for human diseases.

To bring such information to those who need it requires a wide range of communications media, and Sea Grant programs around the Nation employ publications, news announcements, audiovisual productions, and exhibits. Those same communications techniques are also used to fulfill another part of the Sea Grant mandate: informing various segments of the general public of the importance of the Nation's marine resources, and of the activities of the National Sea Grant College Program in relation to them.

Because public information work is so integral a part of Sea Grant management, virtually all programs have components to provide communications expertise. This cadre of writers, editors, audiovisual specialists, and public relations professionals is organized formally as the Sea Grant Communicators Network. The communicators and their programs are the "subject area" of the Information and Awareness arm of the Office of Sea Grant.

In addition to providing a link for communications activities throughout the Sea Grant program, Information and Awareness also serves as a channel to keep appropriate elements of the Federal government apprised of Sea Grant activity and to provide information about Sea Grant to the general public.

Annually, the Office of Sea Grant receives hundreds of requests for information, ranging from general questions about the ocean from school children to inquiries regarding the findings of specific Sea Grant projects. During the biennium, Information and Awareness established a comprehensive system for responding to such queries, the nucleus of which is a five-year working collection of Sea Grant publications at the Office of Sea Grant.

Highlights

Publications. Hundreds of publications were produced by Sea Grant programs during the biennium, ranging from technical reports to books and including newsletters, fact sheets, press releases, monographs, and annual program reports. The following are highlights of major publications produced in the network:

- *Aquaculture 1980,* a digest of aquaculture research and development in the United States and some foreign nations, was produced on behalf of the network by Delaware Sea Grant.
- The first in a series of books on Puget Sound was published by Washington Sea Grant as part of a joint project with the NOAA Office of Marine Pollution Assessment and the Environmental Protection Agency.
- The National Sea Grant Communicators Committee developed a *Reporter's Directory to Sea Grant Research* which was published by the University of Southern California Sea Grant Program.
- The Sea Grant programs of Minnesota, Wisconsin, and Michigan collaborated to produce a guide to boat launching areas on Lake Superior and included weather and safety information.
- In cooperation with the Office of Sea Grant, the Council for National Cooperation in Aquatics published a pocket-sized first aid and safety booklet for boaters and divers.

Sea Grant Today. During the biennium the national magazine of Sea Grant marked its tenth anniversary. Starting out in 1970 as a 16-page monthly with primarily a Sea Grant audience, *Sea Grant 70s* is now *Sea Grant Today* and continues to be an important element in the transfer of information. It is published on behalf of the network at Virginia Polytechnic and State University and has grown to approximately 20,000 circulation by the close of fiscal year 1981. Its audience includes a broad spectrum of the marine community.

The publication's utility also has increased. Articles from it are reprinted in other publications with increasing frequency. The magazine and articles in it have won several awards during the biennium, most notably from the Society for Technical Communication and the National Federation of Press Women.

Because public information is so integral a part of Sea Grant, virtually all programs have components to provide communications expertise.

Audiovisual. Sea Grant has used other media in addition to print.

- *Earthwatch,* a public affairs radio series produced by the Wisconsin Sea Grant Institute, was broadcast by 100 stations in the upper midwest, reaching 4.5 million listeners each month.
- *Mammals of the Sea,* a 30-minute film explaining the relationships between marine mammals—seals, sea lions, otters, whales—and man in the Pacific northwest was produced by the Oregon Sea Grant Program. The film has not only been aired numerous times on public and commercial TV, it has won awards in national and international competitions.
- *Sea Grant,* a 28-minute film describing the National Sea Grant College Program, was produced by NOAA Public Affairs and copies distributed to the programs for local use, including TV distribution.

Conferences. With the designation Year of the Coast, 1980 became an important year for Sea Grant communications as most programs became involved in community exhibits and other types of public information projects. The year was also the tenth anniversary of NOAA, and several programs participated in events marking the occasion.

Florida Sea Grant helped to sponsor Coastal Zone '80, held in Orlando, and Wisconsin Sea Grant participated in the National Water Safety Conference in Chicago. Sea Grant Information and Awareness worked with both programs in participating in those national meetings.

During the biennium, the Office of Sea Grant and local Sea Grant programs also participated in the following major conferences: the 1981 annual Boy Scout Jamboree, held in Fredricksburg, Virginia; Fish Expo, Seattle and Boston; the American Library Association 100th annual conference; Oceans '80 and Oceans '81, the National Marine Education Association conference in Galveston, Texas; and "The Awakening," a Washington, D.C. celebration of the continuing recovery of the Potomac River which involved the Delaware, Maryland, and Virginia Sea Grant programs.

UNDERSEA RESEARCH

The National Picture

With more divers diving—for research, profit, or pleasure—underseas research has gained commercial importance. The population of skin and scuba divers has reached the hundreds of thousands, but many medical aspects of diving are still poorly understood. And lack of information can lead to injuries and fatalities.

Answering underseas research questions calls for experts from the disparate fields of biology, physiology, engineering, resource assessment, and education. And the best selection of these experts can be found at the universities. Sea Grant can tap into universities for research expertise and, through its extension staff, bring the divers' questions to university researchers and, in turn, bring the solutions back to the divers. These capabilities have kept Sea Grant a front-runner in undersea research.

Research results have been significant: one project turned up the fact that those who drown in cold water —even after relatively long exposures —can often be saved. Through Sea Grant's extension agents and communicators, this information has reached the public, received national and international acclaim, and, most important, saved lives. Sea Grant and the Coast Guard continue to run cold-water survival classes.

Sea Grant has also studied effects of water pressure on the physiology of divers, especially women divers. And, similarly, Sea Grant extension staff have passed along the information to interested divers.

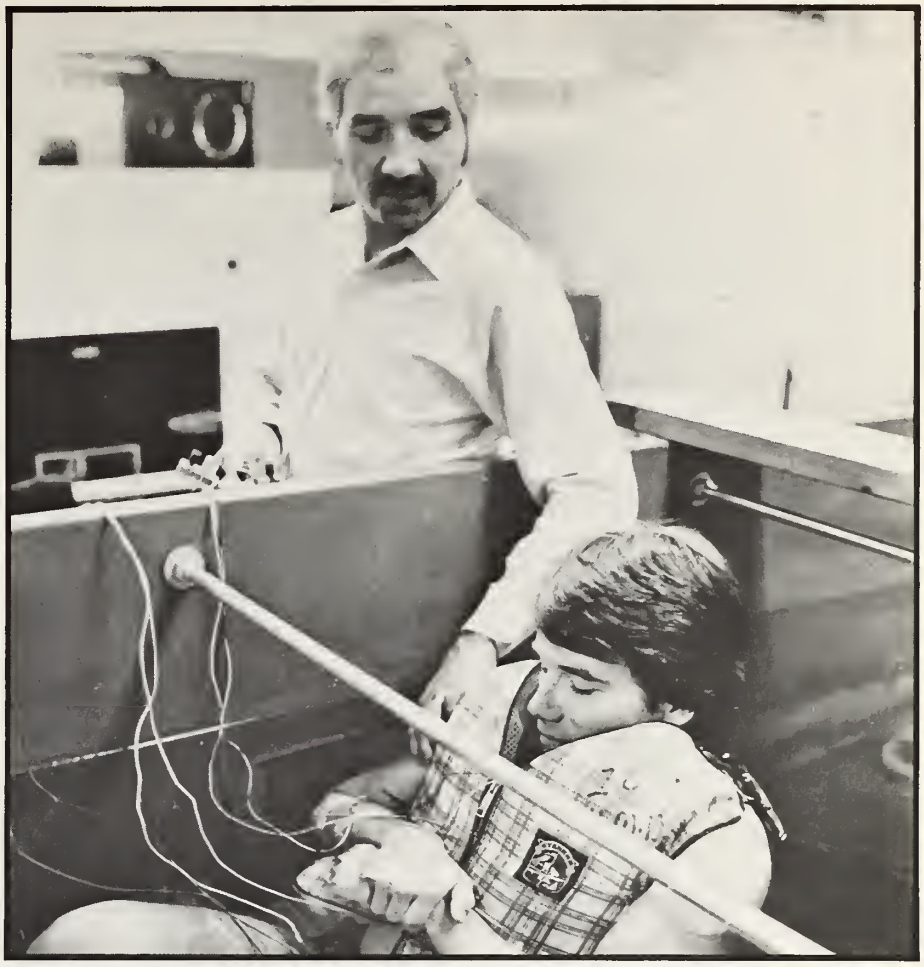
The population of divers has reached the hundreds of thousands, but many medical aspects of diving are still poorly understood.

Research shows that those who drown in cold water can often be saved—even after long exposures.

With regard to the NOAA Undersea Research Program, most of the principal investigators using the regional facilities are or have been Sea Grantees.

New shallow- and deep-sea life support systems enable divers to explore the ocean floor and its resources. To perform these tasks effectively and safely, safety procedures, physiological information, and decompression schedules are critical, and so are more effective and economical remote-controlled, unmanned underwater vehicles.

With all our technological advances, diver education will be not only useful but necessary. Sea Grant will continue research and training in the many facets of undersea research.



This simulation tank lets researchers monitor the body's response to frigid water temperatures. This is part of Sea Grant work on hypothermia.

Diver Physiology and Safety

Sea Grant has explored cold-water immersion (hypothermia), flotation devices for the handicapped, water-related fatalities, decompression sickness, and diving physiology for women. Three projects at the University of Minnesota investigate different aspects of cold-water immersion (for example, how alcohol, shiver, skin, and body temperature metabolism are related). Another project explores the diving reflex—when the blood is shunted from the extremities because of the cold—and how alcohol affects the cardiovascular system in cold water. A third study deals with cold-induced irregular heartbeats in normal and enlarged hearts. Another group of Sea Grant researchers has developed a personal flotation device effective for the physically handicapped. The U.S. Coast Guard has supported this project with pass-through funds. These research projects have led to the production of three new lines of personal flotation devices and thermal suits, grossing approximately $15 million.

Michigan's four-year study of cold-water drowning has increased awareness that victims immersed in cold water need not die if someone correctly resuscitates the victim immediately. As a result, cold-water drowning deaths have decreased nationally.

A Sea Grant researcher at Texas A&M University is analyzing data on water-related fatalities, to develop and disseminate safety information on drowning prevention programs and on management approaches to reducing water-related accidents.

Divers can get decompression sickness when they come up too fast to get the dissolved nitrogen out of their system. Researchers at the University of Hawaii are testing methods, based upon the physics of gas bubble dissolution in gelatin, to improve decompression sickness treatment. Sea Grant is also investigating the physical factors of gas bubble disease which will be used to prepare a comprehensive, improved set of decompression schedules.

A series of studies of diving physiology at the University of Wisconsin will advance our understanding of the human factors that affect the depth, duration, productivity, and safety of underwater work and the improvement of diving techniques and equipment. This effort involves

developing and coordinating diving physiology research, the research aspects of cardiorespiratory effects of immersion, carbon dioxide retention, and decompression in pregnancy. Do standard decompression tables—designed for men—apply to pregnant women? Another related study looks at how decompression affects animal fetuses.

Divers subject themselves to sharp pressure changes and concentrations of nitrogen in their blood. Currently 100,000 women scuba dive, but we don't know whether diving poses any particular physiological risks to them. Sea Grant researchers at Texas A&M University and at Michigan have been investigating whether diving is risky for women; for pregnant women or their fetuses; for women taking oral contraceptives; or whether women are any more susceptible to shifts in moods or changes in motor skills during any part of their menstrual cycle. Most of these experiments use sheep as subjects. In the future Sea Grant will reconcile data from these various studies to conclude what happens to women divers.

Sea Grant's experiments with animals that physiologically resemble humans have confirmed that rapid pressure changes can harm a fetus under some conditions.

Resource Research

Sea Grant has also focused on the use of submersible and hydroacoustic techniques for resource assessment. Researchers at Rutgers have engaged in a three-year cooperative effort with the National Marine Fisheries Service (NMFS), the NOAA Underseas Research Program (NURP), the Harbor Branch Foundation, and the fishing industry to investigate the role, population dynamics, and the long-line fishing gear used to catch tilefish. Observing from an undersea vehicle, the Sea Link, proved a unique and effective way to study tilefish and how to catch them. Because of this effort, tilefish are now sold in New York and New Jersey supermarkets; markets may expand to other mid-Atlantic states.

Two projects at the University of Washington include the investigation of hydroacoustic resource assessment techniques to determine specific fish populations. Extended jurisdiction has brought more responsibilities for fisheries managers and environmental planners; these groups need more information on fish abundance to meet their added responsibilities. These studies could result in increased allowable harvests and increased economic benefits.

Undersea Technology

Tapping resources of our marine environment demands the improvement of unmanned underwater work vehicles, the development of underwater breathing devices, and the application of navigation using sound waves. MIT scientists are working with remote-controlled vehicles that do their work underwater without a driver or diver. A related project, conducted at MIT and Woods Hole Oceanographic Institute, is developing an underwater communication system for untethered vehicles and sensors.

Wisconsin researchers have developed better equipment for breathing underwater that will be built into new designs for skin diving, snorkeling equipment, for air supply systems capable of providing divers with high-pressure fresh air, and for new scuba regulators that minimize breathing resistance, allow for rebreathing of exhaled gases, and function in ice without freezing.

Florida Sea Grant will determine the most appropriate and powerful acoustic signals for diver homing and navigation. This will make scientific, commercial, military, and recreational diving more effective and safer.

Underwater survival and safety will remain Sea Grant's highest priorities. Addressing these areas calls for research in hypothermia, diving physiology, and hyperbaric treatment, and then getting the research information to those who can use it (for example, medical doctors, hospitals, divers, Navy personnel, Red Cross, and NOAA diving and undersea research programs).

AFFIRMATIVE ACTION

Sea Grant strives to ensure that opportunities for education, employment, and recreation in the marine environment are available to all.

As opportunities for education, employment, and recreation continue to expand in the marine environment, Sea Grant strives to ensure that these opportunities are not only available to all, but that women, minorities, the elderly, and the handicapped are made aware of education and training, scientific research activities, careers, and recreational opportunities on our Nation's four seacoasts.

In order to provide the expertise and vision for effective and comprehensive affirmative action throughout the Sea Grant network, the Office of Sea Grant in 1980 established an Affirmative Action Committee to review programs and suggest appropriate directions.

Nationwide, Sea Grant offers a variety of programs and services designed to interest women and minorities in pursuing careers in the marine sciences and to educate the general public among minority groups about the importance of our ocean and coastal resources.

Highlights

• Approximately half the Sea Grant programs offered some form of fellowships to graduate and undergraduate students during the biennium, and each included members of one or more minority groups. In particular, the American Indians in the Marine Sciences program at the University of Minnesota is designed to recruit native Americans to the marine and aquatic sciences.

• A special project at Norfolk State University (Virginia) supported minority students in marine and environmental journalism.

• The Mississippi/Alabama Sea Grant Consortium sponsored a special diving program for students at Jackson State College, a traditionally black institution.

• Seven traditionally white universities developed joint programs with traditionally black colleges to attract minority students to marine science. These include: Oregon State with the University of Arkansas at Pine Bluff; Duke University with Johnson C. Smith University (North Carolina); MIT with Howard University; the University of Alabama, Birmingham, with Talladega College; the University of Georgia with Atlanta College; the University of South Carolina with South Carolina State College; and the University of Maryland with Maryland Eastern.

• In New York City more than 4,000 inner-city youths participated in an urban fishing program sponsored by the New York Sea Grant Institute.

• The University of Southern California offered a "hands-on" waterfront experience for visually handicapped children as well as marine education materials in Spanish.

• In California, Texas, and Louisiana, Marine Advisory staff have been active in assisting with the assimilation of Southeast Asian refugee fishermen into American society by providing publications and programs in their native languages that explain U.S. regulations and procedures.

• The Sea Grant programs in New York, New Jersey, Virginia, and Minnesota have worked formally with the Department of Agriculture's Expanded Food and Nutrition Program to teach seafood preparation and use to inner-city persons. Other Sea Grant programs provided similar programs of their own.

APPENDICES

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Thomas E. Murray	Program Director for Sea Grant International Program
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* Part-time assignment to Sea Grant

Sea Grant Review Panel 1980

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Sea Grant College Designations

1971
Texas A&M University
University of Washington
Oregon State University
University of Rhode Island

1972
University of Wisconsin
University of Hawaii

1973
University of California System

1975
State University of New York/
Cornell University

1976
Massachusetts Institute of
Technology
University of North Carolina
State University System of Florida
University of Delaware

1978
Louisiana State University

1979
University of Maine/University of
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Program
University of Georgia

1980
University of Alaska

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Grants Awarded, by Fiscal Year and State

	1980		1981	
	Sea Grant Dollars	Matching Dollars	Sea Grant Dollars	Matching Dollars
Alabama* (with Mississippi)				
Mississippi/Alabama Sea Grant Consortium	865,000*	514,409*	910,000*	456,500*
Alaska				
University of Alaska Sea Grant College Program	—	—	2,540,000	2,433,936
Arizona				
University of Arizona	36,000	24,000	32,500	44,000
California				
California Sea Grant College Program	2,407,600	1,058,063	5,166,200	2,547,746
University of Southern California Sea Grant Program	635,000	714,956	615,000	489,323
State Total	3,042,600	1,773,019	5,781,200	3,037,069
Connecticut				
University of Connecticut	109,000	54,500	115,000	81,405
Yale University	39,900	24,000	—	—
State Total	148,900	78,500	115,000	81,405
Delaware				
University of Delaware Sea Grant College Program	1,802,650	1,057,205	1,487,600	1,042,689
District of Columbia				
National Fisheries Institute	26,000	13,000	26,000	15,000
Florida				
Florida Sea Grant College Program	1,681,300	1,275,100	1,675,700	1,131,400
University of Miami	111,600	—	—	—
State Total	1,792,900	1,275,100	1,675,700	1,131,400
Georgia				
Georgia Sea Grant College Program	879,900	733,100	875,000	907,500
Hawaii				
University of Hawaii Sea Grant College Program	2,112,400	1,153,440	1,700,000	1,340,304
Oceanic Institute	76,800	40,519	—	—
State Total	2,188,200	1,193,959	1,700,000	1,340,304
Idaho				
University of Idaho	42,900	29,000	—	—
Louisiana				
Louisiana Sea Grant College Program	1,349,000	725,663	1,250,700	670,145
Maine* (with New Hampshire)				
University of Maine/University of New Hampshire Joint Sea Grant College Program	1,450,000*	919,269*	1,525,000*	896,992*
Maryland				
University of Maryland Sea Grant Program	924,800	548,000	1,000,000	611,187

* Mississippi/Alabama and Maine/New Hampshire operate joint Sea Grant Programs; the funds listed are the total of the single grant award to each joint program.

** This grant to the University of New Hampshire is for the New England Marine Advisory Service (NEMAS).

*** These institutions are now part of the Virginia Graduate Marine Science Consortium and no longer receive individual grants.

Grants Awarded, by Fiscal Year and State—Continued

	1980		1981	
	Sea Grant Dollars	Matching Dollars	Sea Grant Dollars	Matching Dollars
Massachusetts				
Massachusetts Institute of Technology Sea Grant College Program	1,768,500	1,182,550	1,699,000	1,053,110
Harvard University	62,000	23,390	60,000	30,000
Woods Hole Oceanographic Institution Sea Grant Program	883,500	606,557	860,700	525,644
State Total	2,714,000	1,812,497	2,619,700	1,608,754
Michigan				
Michigan Sea Grant Program	1,621,200	846,996	—	—
Minnesota				
Minnesota Sea Grant Program	506,000	284,906	535,000	273,800
Mississippi* (with Alabama)				
Mississippi/Alabama Sea Grant Consortium	865,000*	514,409*	910,000*	456,500*
New Hampshire* (with Maine)				
University of Maine/University of New Hampshire Joint Sea Grant College Program	1,450,000*	919,269*	1,525,000*	896,992*
University of New Hampshire	107,100**	58,000**	107,000**	53,500**
State Total	1,557,100	977,269	1,632,000	950,492
New Jersey				
New Jersey Marine Sciences Consortium	582,200	395,127	504,000	393,390
Rutgers University	—	—	25,000	—
State Total	582,200	395,127	529,000	393,390
New York				
New York Sea Grant Institute	1,836,000	896,811	2,001,000	1,090,257
Society of Naval Architects and Marine Engineers	24,000	43,000	—	—
State Total	1,860,000	939,811	2,001,000	1,090,257
North Carolina				
University of North Carolina Sea Grant College Program	1,045,000	522,500	2,350,000	1,210,000
LaQue Center for Corrosion Technology, Inc.	—	—	62,000	—
State Total	1,045,000	522,500	2,412,000	1,210,000
Ohio				
Ohio Sea Grant Program	301,000	257,300	354,000	242,961
Oklahoma				
University of Oklahoma	150,000	75,000	150,000	75,000
Oregon				
Oregon Sea Grant College Program	2,261,900	1,183,900	2,343,900	1,604,500
Pennsylvania				
Lehigh University	175,000	—	—	—
Rhode Island				
University of Rhode Island Sea Grant College Program	1,664,200	826,060	1,759,500	858,898
National Sea Grant Depository	111,000	—	98,600	—
State Total	1,775,200	826,060	1,858,100	858,898
South Carolina				
South Carolina Sea Grant Consortium	613,700	588,600	525,000	478,400

Grants Awarded, by Fiscal Year and State—Continued

	1980		1981	
	Sea Grant Dollars	Matching Dollars	Sea Grant Dollars	Matching Dollars
Texas				
Texas A&M University Sea Grant College Program	1,844,500	1,367,838	1,787,500	1,513,500
Virginia				
Virginia Graduate Marine Science Consortium	—	—	1,319,000	897,757
Virginia Institute of Marine Science***	797,615	436,100	2,630	—
Virginia Polytechnic Institute and State University***	239,300	171,300	—	—
Virginia Polytechnic Institute—Sea Grant Today	84,700	—	104,400	6,400
University of Virginia***	40,000	20,180	—	—
State Total	1,161,615	627,580	1,426,030	904,157
Washington				
Washington Sea Grant College Program	2,275,300	1,192,900	4,205,500	2,789,100
Wisconsin				
Wisconsin Sea Grant Institute	3,806,000	2,203,000	—	—
Puerto Rico				
University of Puerto Rico Sea Grant Program	54,000	56,800	210,000	159,200
National Total	37,403,565	22,123,039	39,982,430	25,923,541

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Sea Grant International Program

	Developing Country	Grantee Institution	Cooperating Institution	Award
1980	Eleven South Pacific Nations	U. of Hawaii	U. of South Pacific, Institute of Marine Resources	$195,700 (2 years)
	Costa Rica	U. of Delaware	U. of Costa Rica	$320,000 (2 years)
	Colombia	U. of Miami	Colombian Oceanographic Commission and universities	$111,600 (1 year)
	India	Florida Sea Grant Program	India Institute of Technology, Bombay	$ 1,300
	Mexico	Louisiana State U.	U. Nacional Autonoma de Mexico	$ 35,800 (1 year)
	Israel	South Carolina Sea Grant Program	Israel National Oceanographic Institute	$ 70,000 (1 year)
	India	Lehigh University	India Institute of Technology, Kanpur	$175,000 (2 years)
1981	Chile and Mexico	Oregon State U.	Catholic U. of Valparaiso and other universities	$212,500 (2 years)
	Malaysia	U. of Rhode Island	Three Malaysian Universities	$ 99,900 (1 year)

Grants Awarded, by Sea Grant Classification

	1980			1981		
	No. of Projects	Sea Grant Funds	Matching Funds	No. of Projects	Sea Grant Funds	Matching Funds
MARINE RESOURCES DEVELOPMENT						
A. Aquaculture						
01—Crustaceans	14	697,867	745,886	17	610,421	634,606
02—Finfish	22	930,839	675,038	40	1,217,903	927,177
03—Mollusks	19	547,838	389,636	28	904,077	582,610
04—Other Animals	7	222,748	128,967	6	364,860	353,229
05—Plants	11	454,599	286,504	14	482,121	461,388
Sub-Area Total	73	2,853,891	2,226,031	105	3,579,382	2,959,010
B. Living Resources other than Aquaculture						
06—Commercial Fisheries—Biology	60	1,766,755	915,787	69	1,996,753	1,276,266
07—Biological Oceanography	17	641,149	437,372	14	584,737	314,887
08—Pathology of Marine Organisms	16	637,651	393,343	6	210,250	193,531
Sub-Area Total	93	3,045,555	1,746,502	89	2,791,740	1,784,684
C. Mineral Resources						
09—Geological Oceanography	6	117,374	58,580	5	91,292	74,315
10—Mineral Resources—Other	2	82,477	40,541	3	77,999	53,129
Sub-Area Total	8	199,851	99,121	8	169,291	127,444
D. Marine Biomedicinals and Extracts						
11—Enzymes	1	16,300	16,000	1	16,000	8,900
12—Biomedicinals	8	338,334	202,832	9	412,237	244,630
13—Marine Extracts—Other	12	335,246	168,279	15	446,274	258,295
Sub-Area Total	21	689,880	387,111	25	874,511	511,825
Total Marine Resources and Development	195	6,789,177	4,458,765	227	7,414,924	5,382,963
MARINE SOCIO-ECONOMIC AND LEGAL RESEARCH						
A. Marine Socio-Economics						
14—Marine Economics	26	837,789	386,177	40	1,149,200	754,170
B. Ocean Law						
15—Coastal	8	213,778	171,886	8	236,255	257,464
16—International	4	120,075	77,365	3	85,410	87,573
17—Ocean Law—Other	2	103,942	60,847	3	85,410	87,573
Sub-Area Total	14	437,795	310,098	14	469,752	421,083
C. Marine Recreation						
18—Sports Fisheries	9	204,433	173,757	9	200,143	168,051
19—Other Recreation	11	295,489	185,199	5	113,024	69,110
Sub-Area Total	20	499,922	358,956	14	313,167	237,161
D. Socio-Political Studies						
20—Socio-Political Studies	20	414,872	551,316	16	276,293	304,803
Total Marine Socio-Economics and Legal Research	80	2,190,378	1,606,547	84	2,208,412	1,717,217
MARINE TECHNOLOGY RESEARCH AND DEVELOPMENT						
A. Ocean Engineering						
21—Life Support Systems	0	—	—	0	—	—
22—Seafloor Engineering	2	127,500	90,063	3	142,900	85,927
23—Vehicles, Vessels, and Platforms	6	140,651	87,130	14	353,162	341,407
24—Materials and Structures	12	476,459	201,988	14	570,211	248,081
25—Coastal Engineering	16	645,033	290,668	19	526,574	356,112
26—Engineering—Aquaculture	1	76,800	40,519	3	99,692	86,239
27—Dredging	2	72,400	11,574	1	13,619	12,349
28—Ocean Engineering—Other	9	362,650	125,751	17	866,718	230,116
Sub-Area Total	48	1,901,493	847,683	71	2,572,876	1,360,231

Grants Awarded, by Sea Grant Classification—Continued

	1980			1981		
	No. of Projects	Sea Grant Funds	Matching Funds	No. of Projects	Sea Grant Funds	Matching Funds
B. Resources Recovery and Utilization						
29—Behavioral Sciences	2	87,000	56,180	2	53,745	29,664
30—Commercial Fisheries Technology	12	279,236	141,549	9	344,943	251,707
31—Diver Engineering	1	97,745	27,560	0	—	—
32—Diver Physiology	6	522,625	210,852	5	152,354	84,202
33—Manned Submersibles	0	—	—	0	—	—
34—Man-In-The-Sea	4	75,034	39,906	4	70,657	32,521
35—Seafood Science and Technology	30	891,611	563,559	51	1,505,862	965,246
Sub-Area Total	55	1,953,511	1,039,606	71	2,127,561	1,363,340
C. Transportation Systems						
36—Ports, Harbors, and Offshore Terminals	1	37,118	18,132	1	17,818	10,200
37—Transportation Systems—Other	6	164,889	54,370	4	108,920	79,261
Sub-Area Total	8	202,007	72,502	5	126,738	89,461
Total Marine Technology Research and Development	110	4,056,751	1,959,801	147	4,827,175	2,813,032
MARINE ENVIRONMENTAL RESEARCH						
A. Research and Studies in Direct Support of Coastal Zone Management Decisions						
38—CZM Social Sciences	17	494,911	427,053	9	223,238	176,348
39—CZM-Natural Sciences and Engineering	23	886,529	347,559	23	693,168	336,564
Sub-Area Total	40	1,381,440	774,612	32	916,406	512,912
B. Ecosystems Research						
40—Ecosystems Research	33	1,236,606	477,395	35	1,234,434	748,391
C. Pollution Studies						
41—Oil Spills	3	69,800	66,898	3	71,092	45,775
42—Pesticides	5	86,721	60,503	2	51,888	26,651
43—Thermal and Radioactive	0	—	—	0	—	—
44—Metals	9	145,847	130,513	5	111,938	136,542
45—Pollution-Other	33	1,136,798	540,198	30	678,578	525,760
Sub-Area Total	50	1,439,166	798,112	40	913,496	734,728
D. Environmental Models						
46—Physical Processes	14	502,996	155,893	18	569,353	154,765
47—Biological Processes	16	598,821	227,972	13	303,501	138,418
48—Environmental Models—Other	1	14,415	7,036	2	112,586	12,554
Sub-Area Total	31	1,116,232	390,901	33	985,440	305,738
E. Applied Oceanography						
49—Applied Chemical Oceanography	3	103,345	48,793	3	92,915	73,902
50—Applied Physical Oceanography	14	892,473	122,312	12	425,810	122,378
Sub-Area Total	17	995,818	171,105	15	518,725	196,280
Total Marine Environmental Research	171	6,169,262	2,612,125	155	4,568,501	2,498,049
MARINE EDUCATION AND TRAINING						
A. College Level, Course Development						
51—Chemical Oceanography	0	—	—	0	—	—
52—Geological Oceanography	1	13,000	6,500	0	—	—
53—Physical Oceanography	0	—	—	0	—	—
54—Economics	1	41,616	43,372	1	42,394	36,902
55—Law	1	45,344	36,938	5	144,138	110,004

Grants Awarded, by Sea Grant Classification—Continued

	1980			1981		
	No. of Projects	Sea Grant Funds	Matching Funds	No. of Projects	Sea Grant Funds	Matching Funds
56—Biology	0	—	—	0	—	—
57—Pathology	0	—	—	2	2,707	3,900
58—Seafood Technology	0	—	—	0	—	—
59—Fisheries	1	17,600	23,400	2	38,700	48,300
60—Aquaculture	2	41,400	14,000	2	54,520	61,703
61—Ocean Engineering	4	52,359	170,552	1	—	74,664
62—Course Development—Other	15	388,598	168,137	12	175,654	92,108
Sub-Area Total	25	599,917	462,899	25	458,113	427,581
B. Vocational Marine Technician Training						
63—Commercial Diver Training	0	—	—	0	—	—
64—Oceanographic Technician Training	0	—	—	0	—	—
65—Aquaculture Technician Training	0	—	—	0	—	—
66—Commercial Fisheries Training	3	104,493	171,075	4	96,556	103,200
67—Technician Training—Other	3	50,000	130,600	0	—	—
Sub-Area Total	6	154,493	301,675	4	96,556	103,200
C. Retraining Program						
68—Engineering Retraining	0	—	—	0	—	—
69—Technician Retraining	0	—	—	0	—	—
D. Other Education						
70—Education—Other	70	2,879,385	1,083,215	69	3,082,071	1,325,987
Total Marine Education and Training	101	3,633,795	1,847,789	98	3,636,740	1,856,768
ADVISORY SERVICES						
A. Extension Programs						
71—Extension Agent Services	30	4,580,537	2,628,912	41	6,499,621	4,790,938
72—Extension Course Programs	2	79,167	119,036	2	103,428	96,534
73—Extension Programs—Other	7	772,674	637,270	8	1,177,207	804,642
Sub-Area Total	39	5,432,378	3,385,218	51	7,780,256	5,692,114
B. Other Advisory Services						
74—Conferences, Institutes, etc.	1	24,036	63,267	3	55,075	52,552
75—Public Education Programs	8	162,107	236,791	8	380,139	533,994
76—Publications, Audio Visuals, etc.	17	1,220,766	725,140	26	1,624,588	570,644
77—Advisory Services—Other	31	3,312,088	1,598,128	22	2,096,107	1,225,585
Sub-Area Total	57	4,718,997	2,623,326	59	4,155,909	2,382,775
Total Advisory Services	96	10,151,375	6,008,544	110	11,936,165	8,074,889
PROGRAM MANAGEMENT AND DEVELOPMENT						
A. Program Administration						
78—Program Planning	4	258,063	179,551	3	183,720	186,633
79—Program Administration	29	2,605,301	2,480,257	33	2,789,536	3,104,001
Sub-Area Total	33	2,863,364	2,659,808	36	2,973,256	3,290,634
B. Program Development						
80—Program Logistic Support	5	290,608	348,556	5	297,600	65,410
81—New Applications Development	19	1,258,855	621,104	29	2,119,657	385,104
Sub Area Total	24	1,549,463	969,660	34	2,417,257	450,514
Total Program Management and Development	57	4,412,827	3,629,468	70	5,390,513	3,741,148
GRAND TOTAL	810	37,403,565	22,123,039	891	39,982,430	26,084,066

Funds Managed for Other Agencies*

Agency	1980 No. of Projects	1980 Amount	1981 No. of Projects	1981 Amount
MARINE RESOURCES DEVELOPMENT				
Environmental Protection Agency (EPA/TOX)	1	30,800	—	—
National Marine Fisheries Service (NOAA)	3	15,600	4	98,300
Office of Research and Development (NOAA)	1	226,000	—	—
MARINE SOCIO-ECONOMICS AND LEGAL RESEARCH				
Coast Guard (DOT)	1	2,000	—	—
Department of Interior	1	69,650	1	131,800
Department of State	1	35,000	—	—
Maritime Administration (DOC)	1	5,000	—	—
National Marine Fisheries Service (NOAA)	2	21,800	1	10,000
National Science Foundation	—	—	1	5,000
Office of Coastal Zone Management (NOAA)	1	64,000	—	—
Office of Marine Minerals (NOAA)	1	35,000	1	6,000
Office of Marine Minerals and Economics (NOAA)	—	—	1	35,000
Office of Marine Pollution Assessment (NOAA)	—	—	1	17,100
Office of Policy and Planning (NOAA)	—	—	1	22,500
Office of Research and Development (NOAA)	1	5,000	—	—
MARINE TECHNOLOGY RESEARCH AND DEVELOPMENT				
Coast Guard (DOT)	4	489,000	3	160,100
Department of Defense—Army	1	232,900	1	145,700
Department of Defense—Navy	1	45,300	5	193,700
National Marine Fisheries Service (NOAA)	3	42,000	2	25,000
Office of Marine Minerals and Economics (NOAA)	—	—	1	44,700
Office of Policy and Planning (NOAA)	2	104,900	—	—
Office of Research and Development (NOAA)	2	56,700	—	—
MARINE ENVIRONMENTAL RESEARCH				
Coast Guard (DOT)	1	30,000	—	—
Department of Defense—Army	—	—	7	91,790
Department of Defense—Navy	1	25,000	1	25,000
Department of Interior	—	—	8	52,015
Environmental Data and Information Service (NOAA)	2	64,400	—	—
Environmental Protection Agency (EPA/TOX)	5	281,100	9	978,700
National Marine Fisheries Service (NOAA)	2	155,000	1	30,000
Office of Coastal Zone Management (NOAA)	—	—	1	22,500
Office of Marine Pollution Assessment (NOAA)	1	100,000	1	100,000
Office of Policy and Planning (NOAA)	—	—	1	30,000

* Often referred to as "pass-through" funds.

Funds Managed for Other Agencies*—Continued

	1980		1981	
	No. of Projects	Amount	No. of Projects	Amount
MARINE EDUCATION AND TRAINING				
Department of Defense—Army	—	—	1	13,095
Department of Interior	—	—	1	1,785
Maritime Administration (DOC)	1	43,600	—	—
Miscellaneous Assistant Administrators (NOAA)	—	—	1	30,000
National Marine Fisheries Service (NOAA)	1	22,500	—	—
Office of Coastal Zone Management (NOAA)	1	16,985	—	—
Office of Marine Pollution Assessment (NOAA)	1	45,000	1	22,000
MARINE ADVISORY SERVICES				
Coast Guard (DOT)	—	—	2	11,400
Environmental Data and Information Service (NOAA)	4	95,000	6	19,900
National Ocean Survey (NOAA)	1	10,000	—	—
National Weather Service (NOAA)	—	—	1	35,000
NOAA Undersea Research Program	—	—	1	2,800
Office of Coastal Zone Management (NOAA)	2	75,000	—	—
Office of Marine Pollution Assessment (NOAA)	2	234,600	1	40,000
Office of Policy and Planning (NOAA)	—	—	1	10,000
Office of Ocean Engineering (NOAA)	1	30,000	—	—
PROGRAM MANAGEMENT AND DEVELOPMENT				
Department of Defense—Army	—	—	1	5,115
Department of Defense—Navy	—	—	1	700
TOTALS	53	2,718,485	70	2,518,800

* Often referred to as "pass-through" funds.

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

JUN 28 1983

Honorable Malcolm Baldrige
Secretary of Commerce
Washington, D. C. 20230

Dear Mac:

This is in response to your request for our views on the Biennial Report to the President and Congress on the National Sea Grant College program.

The Sea Grant program was originally visualized as the moving force in the creation of a network of colleges and universities with strong programs in marine education and research. The goal has been largely realized. Nineteen institutions have been awarded Sea Grant College status. Because the Sea Grant program has been successful in encouraging the collaboration of universities, industry, and local government for the purpose of enhancing the marine economy, its functions need no longer be financed by the Federal Government.

The established Sea Grant Colleges and institutions can be expected to find support for their projects from these States and elements in the private sector who benefit from the program.

Thank you for the opportunity to provide our views.

Sincerely,

David A. Stockman
Director

THE WHITE HOUSE

WASHINGTON

May 31, 1983

Dear Secretary Baldrige:

In reference to your letter of May 13, 1983, we have reviewed the draft of the Biennial Report to the President and Congress on the Sea Grant College Program and find it perfectly acceptable.

Yours truly,

G. A. Keyworth
Science Advisor to the President

The Honorable Malcolm Baldrige
Secretary of Commerce
Washington, D.C. 20230

edited and produced by Bruce M. Kantrowitz

special thanks to the New York Sea Grant Institute,
particularly Lesley Weissman for design and Pat Sacca for word
processing and other editorial assistance.

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